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In an attempt to improve the teaching of conservation in elementary and junior high schools, a set of integrated sequential core units was formulated and tested in five Wyoming school districts during the fall and early winter of 1968. Based on a total sample of 840 elementary students (38% usable response) and 960 junior high students (49% usable response), statistical analyses indicated that teachers' use of the guides and their classroom presentations were successful in stimulating student interest in conservation problems. With the exception of the unit for grade 6 on minerals and oils, which proved too difficult and will require rewriting, consistent student test performances in all school districts and in all other grades indicated that the materials are at an appropriate grade level of difficulty. Findings support the value of the sequential resource unit approach to both the teacher and the student. In addition to an introductory guide to Wyoming's natural resources and their management, complete curriculum core units for each grade are appended as follows: (1) Wildlife, (2) Water, (3) Soils, (4) Grassland, (5) Forests, (6) Minerals and Oil, (7) Pollution, (8) Human Resources, and (9) Environmental Usage. (JK)

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CONSERVATION EDUCATION IMPROVEMENT

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CONSERVATION EDUCATION IMPROVEMENT

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July 12, 1969

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgement in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent Office of Education position or policy.

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SUMMARY

Despite efforts which have increased the teaching of conservation in public schools, the public still remains apathetic in their attitudes toward and habits concerning natural resources. Little or no attempt has been made to develop and organize meaningful concepts of conservation principles in the elementary and junior high schools. It is imperative to eliminate boring repetitive instruction at each grade level and to introduce new, integrated materials to accelerate development of effective future conservation practices.

In an attempt to develop more effective conservation teaching practices, the objectives of this study were:

1. To develop integrated conservation core units for teachers and students in grades 1 through 9.
2. To explore the length of time needed to effectively teach conservation principles at garde levels of 1 through 9.
3. To ascertain what effect the discovery and analytical approach of the units would have on student awareness and interest in conservation.

Sequential core units developed were:

Grade 1 - Wildlife
Grade 2 - Water
Grade 3 - Soils
Grade 4 - Grassland
Grade 5 - Forests
Grade 6 - Minerals and Oil
Grade 7 - Pollution
Grade 8 - Human Resources
Grade 9 - Environmental Usage

Evaluations of the units were based on pre-test and post-test student responses, teacher questionnaire responses and differences between 5 contrasting school districts. Main affects and two way interactions were statistically analyzed with a four factor random design analysis of variance.

Teacher evaluations of the guides developed indicated they were very helpful, with two exceptions. The "Minerals and Oil" guide was inadequate, too difficult and requires rewriting. The evaluation of the "Teachers

Reference" section in all guides indicated that most school refereence resources in their libraries must be improved to adequately support this curriculum addition.

The length of time suggested as an ideal period for presentation of each unit was 3 to 4 weeks.

Statistical analysis of the student test responses indicated that the discovery and analysis approach was successful. The material presented to each grade level appeared to be at an appropriate level of difficulty. Higher student performance was consistently recorded in the district having more teachers with background in conservation courses or workshops. Cultural characteristics of the districts studied appeared to exert little or no influence on student test responses. The general consistency in test performance between grades and different subjects, indicated that the integrated resource unit approach can be successful in teaching conservation in public schools.

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INTRODUCTION

Although, the effort of teaching conservation in public schools has generally increased during the last 10 years, the basic problem has not been solved -- that of changing public attitudes and habits toward conserving natural resources. Popular literature is filled with preached generalities, a dubious means of persuading the populace to change their pattern of behavior. Highsmith, Jensen and Rudd (1962) maintain that (1) inability to implement important conservation practices has been due to a lack of public association with the resources which support our economy; and (2) in order to bring about action concerning conservation problems, the public must be enlightened. To expedite enlightenment, a number of states have enacted laws to force exposure of conservation principles upon students and teachers. However, their programs appear to have difficulties as noted by Hurd (1964). Better enlightenment will come from formal education not from law making. Highsmith, Jensen and Rudd (1962) stressed as a real challenge in conservation, the enlightenment of the public through the schools.

At their March convention in 1946, the Izaak Walton League of America formed a Committee on Conservation Education and urged:

> the Executive Board to continue with the aid of educators, conservationists, and scientists to work out a national policy of conservation education and seek to have this policy established in our public school systems as a part of our national way of life.

The National Committee on Policies in Conservation Education (1947) set forth a Proposed Program in Conservation Education. Point five under their proposed program contained the following declaration:

> The curriculum for children should ... embody such environmental experiences ... (as) camping, field trips, soil testing, planned care of plant and animal life, supplemented by significant vicarious experiences ... essential to the development of a truly motivating conservation education program.

Point six continued,

> Corresponding continuous educational research is needed to determine the techniques and procedures essential for putting conservation practices into effect. Educational research should deal with general education and with professional education, and should include technical studies as well as those directed towards the preparation of appropriate instructional materials.

However, to date, implementation of these concepts is far from reality.

Little work has been directed toward organizing meaningful concepts of conservation in the elementary and junior high school into a "conceptual scheme." No formal research in the elementary school is available as to what concepts of conservation education are known at a particular grade level nor at what level the concepts of conservation would be best assimilated. No real attempt to coordinate concept formation of conservation principles through the elementary and junior high school has been made. It is possible that teachers may be defeating their own purpose by echoing instruction at each grade level rather than presenting fresh integration of new material commensurate with the maturation of the students. Virtually no materials emphasizing discovery and the analytical method have been prepared on the subject. Boredom in conservation might be one cause of public apathy toward resource problems. It is imperative that conservation materials be renovated and improved to utilize the latest educational techniques available to us today.

The purpose of this investigation was to develop better instruments of persuasion and implementation to give the elementary and junior high school educators a better means of rapidly developing effective conservation practices. Specifically the objectives of this study were:

1. To develop a set of integrated core units for each grade level which will stress new aspects of conservation principles and at the same time maintain a highly organized yet stimulating approach for both teacher and student.
2. To explore the length of time needed to effectively teach conservation principles at grade levels 1 through 9; and to explore the most efficient and effective means of

weaving the conservation theme into the curriculum.

3. To ascertain what effect the discovery and analytical approach would have on increasing the student's awareness and interest in conservation problems.

METHODS

Sequential teaching sources stressing new aspects of conservation material at each grade level were not available from publishing sources. Such materials were developed by our group according to the following topic sequence:

Grade 1 - Wildlife
Grade 2 - Water
Grade 3 - Soil
Grade 4 - Grasslands
Grade 5 - Timber
Grade 6 - Minerals and Oil
Grade 7 - Pollution
Grade 8 - Human Resources
Grade 9 - Environmental Usage.

The order of topics was based on the assumption that grade 1 students love all animal life and have a natural feeling for that resource that would not be true for the other resources. The remaining elementary sequence was determined on the basis of natural evolutionary processes and advancing academic development of the student. Grades 1 through 6 would then be building knowledge of basic resources. Grades 7 through 9 would be integrating that knowledge. In the entire scheme, as the student advanced through each grade, a new conservation topic would be introduced. This did not prevent discussing the relation of other resources to that topic. However, it eliminates all duplication of the same topic, e.g., wildlife or forestry in all 9 grades. These units were further supplemented by the publication Wyoming's Natural Resources and Their Management (Appendix B).

Based on the subject matter of these resource units, pre-tests and post-tests were designed to evaluate the students' knowledge before exposure to the unit and to determine the amount of information gained after exposure to the unit (Appendix C).

All units and examinations were given a preliminary trial in a combination rural and urban school district to detect weaknesses and evaluate the level of each presentation. A teacher evaluation form was devised and tested at the same time (Appendix C). Evaluation of this trial produced some modifications which were incorporated in the final units, tests, and teacher evaluations.

A teacher response index was developed from the five questions of the questionaire. Since each question could receive a response value from 1 to 5, the responses to single questions were summed as to level of response and to the number of teachers and then averaged. The sum of these averages was then divided by the maximum value possible for the set of five questions. This value is a relative index of response which may be used to examine the rating the teachers gave their respective units. The averaged values for each question were then used to examine the rating teachers gave to the individual sections of their respective teacher's guides. This permited a section by section comparison among units.

Selection of the school districts for this pilot study was largely based on cultural, economic and demographic considerations. The five school districts selected were:

a. City or District 1 - Railroad, university and ranching activities.
b. City or District 2 - Mining, oil, timber, ranching and recreation activities.
c. City or District 3 - Military base, railroad, ranching and oil activities.
d. City or District 4 - Mining, railroad and ranching activities.
e. City or District 5 - Irrigated farming, oil and recreation activities.

Within each school district, a minimum of three classes in each of the grades 1 through 6 were selected by the school administrators. These classes were taught by different instructors and usually were in different schools. For grades 7 through 9, one or more teachers with several sections of the same grade subject area, e.g., general science, biology or social science, were selected by the administration for initiating those respective conservation units.

Administration of the pre-tests, teaching of the specific units and administration of the post-tests were conducted in all five districts during the fall and early winter of 1968. Fourteen student observations were randomly selected by sex, by grades 1 through 6 and by school district; likewise, 40 were randomly selected by sex, by grades 7 through 9 and by school district. In all cases, the maximum number of observations were determined by the smallest number of students of one sex from the smallest class participating in the testing program. The sample size from the elementary population was 840 students and 960 students from the grades 7 through 9 population. Unfortunately, only 38% of the tests in grades 1 through 6 and 49% of the tests in grades 7 through 9 were usable. Factors contributing to this low percentage were numerous, e.g., unusable individual tests, entire classes where test data were unusable and failure of committed teachers to participate in the program.

Statistical comparisons of test, sex, city and grade observation characteristics were conducted with a four factor random design (fixed effects) analysis of variance. Only two way interactions and main effects were evaluated. The assumption model used was:

$$x_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + \lambda_l + (\alpha\lambda)_{il} + (\beta\lambda)_{jl}$$
$$+ (\gamma\lambda)_{kl} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta)_{ij} + \dots$$
$$+ e_{ijkl}$$

where α_i - main effect of tests
β_j - main effect of sex
γ_k - main effect of city
λ_l - main effect of grade

Hypothesises tested were

H_o^1: $\alpha_i = 0$ H_o^2: $\beta_j = 0$ . . . H_o^{10}: $(\alpha\beta)_{ij} = 0$
H_A^1: $\alpha_i \neq 0$ H_A^2: $\beta_j \neq 0$ . . . H_A^{10}: $(\alpha\beta)_{ij} \neq 0$

Using Tukey's method for multiple comparisons of means with equal observations and a known level of significance, contrasts of the means for a main effect or two way interaction were calculated (Guenther, 1964). This procedure is usuable for data that has already been examined. The test statistics, using Scheffe's notation were as follows:

$$T = \frac{1}{\sqrt{n}} q_{1- \ ;r,(n-1)(r-1)}$$

where $q_{1- \ ;r,(n-1)(r-1)}$ was obtained from table values found in Guenther (1964).
n = the number of observations
r = the number of samples to compare

Then assuming the interval of $\bar{x}_{ij} - \bar{x}_{ij'} \neq 0$ the final statistic used became

$$\bar{x}_{ij} - \bar{x}_{ij'} > T\sqrt{MSE}$$
$$\text{or } \bar{x}_{ij} - \bar{x}_{ij'} < q_{1- \ ;r,n-r}\sqrt{\frac{MSE}{n}}$$

A table of differences between $\bar{x}_{.j} - \bar{x}_{.j'}$ was constructed and compared to the test statistic to find significant differences.

A medium sized computer, the CDC 3300, which included floating point hardware instructions among its optional features, was used. It was programmed to provide the means of the various effects for the different analysis of variance designs it ran (Yates, 1968). For this project a 2x10x10x20 dimension specification was read in. The second order interaction sums of squares was calculated as follows:

$$SS_{BxCxD} = \sum_{ijk}\sum\sum \frac{x_{1ijk}^2 + x_{2ijk}^2}{n_{ijk}}$$

When the sums of squares was added over the "A" factor, the denominator became $2(n_{ijk})$. This happened because the n_{ijk} had been calculated over the number of observations in each treatment combination of B, C, and D factors; all the other interactions were handled the same way. The main effects of the sums of squares was calculated as follows:

$$SS_A = \frac{\sum\sum\sum_{ijk} x_{1ijk}^2 + \sum\sum\sum_{ijk} x_{2ijk}^2}{\sum\sum\sum_{ijk} n_{ijk}}$$

The correction factor was:

$$C.F. = \frac{(\Sigma Obs)^2}{n}$$

The analysis of variance total sums of squares was obtained in the following manner:

$$TSS = \Sigma(Obs)^2 - C.F.$$

The rest of the corrected sums of squares were:

A - main effect: SS_A - C.F. (1)

B - main effect: SS_B - C.F. (2)

AxB - interaction: SS_{AxB} - C.F. - (1) - (2)

etc.

The error sum of squares was

$$ESS = TSS - (1) - (2) - \ldots - (15)$$

The degrees of freedom for the first main effect must equal 1. The remaining degrees of freedom were obtained in the usual way, n-1. From the corrected sum of squares, the mean sums of squares was obtained:

$$\frac{\text{Corrected SS}}{\text{D.F.}}$$

The computer checked to see if the error degrees of freedom equaled 0. If it did not, it then would have calculated the error mean square by $\frac{ESS}{EDF}$. Following the ANOVA table, the computer printed out the mean of the observations for each level of the main effects followed by the first order or two-way interactions.

The contrast of means was considered in detail to obtain information concening the value of the design of the C.E.I.P. materials in the environment in which they were tested. The calculation of the critical value and the organization of the tabular differences were as follows:

a. Critical Value = $T\sqrt{\frac{MSE}{n}}$

$$T = \frac{1}{\sqrt{n}}\, q_{1-\ ;r,(n-1)(r-1)}$$

b. General Model of Table of Differences ($\bar{x}_{.j} - \bar{x}_{.j'}$)

	$\bar{x}_{.j}$	$\bar{x}_{.j}-\bar{x}_{.1}$	$\bar{x}_{.j}-\bar{x}_{.4}$	$\bar{x}_{.j}-\bar{x}_{.2}$	$\bar{x}_{.j}-\bar{x}_{.3}$
$\bar{x}_{.5}$	a_5	a_5-e_1	a_5-d_4	a_5-c_2	a_5-b_3
$\bar{x}_{.3}$	b_3	b_3-e_1	b_3-d_4	b_3-c_2	
$\bar{x}_{.2}$	c_2	c_2-e_1	c_2-d_4		
$\bar{x}_{.4}$	d_4	d_4-e_1			
$\bar{x}_{.1}$	e_1				

The mean values for $\bar{x}_{.5}$ are entered as the largest value. The other means follow in descending value. The subtractions are made as indicated and the differences compared to the critical value as computed from the test statistic. The null hypothesis is rejected if $\bar{x}_{.j} - \bar{x}_{.j'} > C.V.$

RESULTS AND DISCUSSION

The general usefulness of the teacher's guides was best measured by the teacher's evaluation response indices summarized in Table 1. Except for two notable instances, the Minerals and Oil Guide and the "Teacher's Reference" were rated as being only slightly less than very helpful. Deferring discussion of the two exceptions, the "Teacher's Discussion" apparently was the most valuable portion of the guides. With the exception of the "Teacher's References," the teachers of grades 1 through 5 found the other sections of the teacher's guides more useful than did the teachers of the upper grades. This trend of decreasing value may, in part, reflect better teacher preparation and wider reading habits at a more difficult level by the teachers of the higher grade levels. On the other hand, there is always a greater challenge for inventing variable, fresh material and approaches for holding interest in the lower grades. These ratings may then reflect greater receptivity to new and variable approaches to teaching at the lower grades; whereas, the higher the grade level, the less exploratory the subject matter becomes and the more concentrated the effort to teach greater amounts of factual material. Lastly, since the teachers of grades 1 through 5 tended to rate most sections evenly, this suggests that the lower level guides were better balanced in usefulness than those of the upper grades. This may have resulted from a change in the activities subsection beginning with grade 7. A lack of adequate library reference material would seriously handicap some of the proposed discussion springboards. Also, time and large classes may have served to discourage some teachers from conducting the proposed field trips or projects. However, in designing each teacher's guide every effort was made to provide activities which could be utilized under a wide variety of classroom conditions and restrictions.

In two instances, the teacher's guides were less than helpful. The "Minerals and Oil" guide was inadequate for several reasons. In the elementary grades, physical sciences are largely ignored. Teachers have little or no background in these areas and the mere indulgence in the simplest physical science vocabulary and terminology easily discouraged the teachers. A similar reaction was observed with exposure to the minerals and oil unit. An attempt was made to bridge this gap with a basic discussion of elements, metals, alloys, etc. The end result was that too much time was devoted to basics and very little to the primary non-renewable mineral and oil resource conservation problems. It was thought that the minerals and oil chapter in the Natural Resources of Wyoming would affect to some degree this deficiency. Such was not the case. The ratings indicate a major reconstruction of this guide is obviously needed.

The poor utility of the "Teacher's References" was attributed largely to those references generally being unavailable or difficult to obtain. This is not a surprising problem for in the development of these teacher's guides and the subsequent trial periods, it soon became apparent that library holdings in the area of natural resources and conservation were in most cases ancient or not existent. To embark on such an integrated conservation program, each school district will necessarily have to provide for the library purchase of several of the suggested references. The suggested sources of free literature would further offset this reference difficulty. With greater experience with a topic, each teacher would probably send, well in advance, for such material and this would be a self-correcting situation.

School district audio-visual inventories are good in some topical areas, i.e., wildlife. Beyond that, they are generally inadequate for up-to-date material. For this reason, a number of free films were listed where possible to counteract economic problems. Where a problem of film selection existed, a variety of options from several different sources were suggested. As with the library holdings, many of the old standby films are more familiar and available, but are not necessarily adequate. The rental of a few carefully selected films each year should be well within the budget of most schools, if free films are not available for a particular time.

The difficulty of selecting these teacher references was recognized early, for nothing serves to dull student interest quicker than the use of dated material which is not particularly relevant to current affairs. This low reference rating is therefore considered to be an indication of the degree of physical support necessary from the school system to update course offerings. Teacher and teaching quality can be no better than the physical support system serving the teacher and the student.

The ideal time required for teaching the unit was not precisely determined. A variety of approaches and time periods produced under different teachers the same result. A general concensus of responding teachers indicated no less than 2 weeks should be devoted to any one of the topics. A widely preferred time period seemed to be 3 to 4 weeks. Many teachers using a 2 or 3 week allotment of time explained that they worked the topic in, wherever appropriate, throughout the school year. Under these circumstances, it seems advisable to leave the specific time length up to each individual teacher with no fewer than 2 weeks being the rule.

The results of the analysis of variance are presented in Table 2. The sequence of effect differences and tests for significance of those effects are presented in the tables of Appendix A. While the test main effect was found to be significant in all grades, useful analysis is best deferred to the second order interactions. Also, differences in test responses between girls and boys were not significant in any grade. Where the F-test suggested significance, use of the more sensitive Tukey's method disproved this effect.

In grades 1 through 6, student response to the tests was not significantly different between the five school districts sampled. However, in grades 7 through 9, District 5 students were able to respond significantly better than two of the four districts. A greater number of

Table 1. Summarized numerical ratings and rating indices of teacher responses on teacher's guide questionnaire.

Topic	Grade Level[a]	Average Rating[b]					Rating[c] Index
		Teacher's Discussion	Teacher's References	Unit Development and Presentation	Resource Unit and Planning	Activities and Concepts	
Wildlife	1	4.2	4.0	3.8	3.8	3.9	0.79
Water	2	4.2	2.4	4.0	3.8	3.8	0.72
Soil	3	3.8	3.1	4.0	3.9	4.0	0.75
Grasslands	4	3.5	3.5	3.6	3.6	3.8	0.70
Forests	5	3.5	2.6	3.8	4.4	3.1	0.70
Minerals and Oil	6	3.5	2.2	3.0	3.1	2.7	0.60
Pollution	7	4.0	2.3	3.3	3.0	3.2	0.63
Human Resources	8	4.0	3.2	3.5	3.2	3.5	0.70
Average		3.8	2.9	3.6	3.6	3.5	0.70

[a] Insufficient response made evaluation of the Grade 9 impossible.

[b] A numerical response where 1 was "no help" to 5 which indicated material was "extremely helpful."

[c] Based on a maximum response of 25 for the five questions.

Table 2. An analysis of variance of conservation pre-tests and post-tests administered in grades 1 through 9 in five Wyoming school districts, 1968

Grades	Effect	D.F.	Mean Square
1 - 6	Test	1	1321.29[a]
	Sex	1	5.64[a]
	City	4	7.98[a]
	Grade	5	66.80[ab]
	Test x Sex	1	0.06
	Test x City	4	0.87
	Test x Grade	5	19.71[ab]
	Sex x City	4	1.67
	Sex x Grade	5	2.09
	City x Grade	20	8.53[ab]
7-9[c]	Test	1	1621.71[a]
	Sex	1	0.32
	City	3	71.27[ab]
	Grade	2	30.94[a]
	Test x Sex	1	0.16
	Test x City	3	24.30[ab]
	Test x Grade	2	28.71[ab]
	Sex x City	3	2.59
	Sex x Grade	2	0.44
	City x Grade	6	41.20[ab]

[a] T-test significant at .05 level.

[b] Tukey's test significant at .05 level.

[c] Absence of grade 9 data from district 4 restricted analysis to the other 4 districts.

teachers of District 5 have, generally, been exposed to more conservation workshop opportunities and/or have participated in more conservation courses than the teachers in the other school districts. Where greater integration and innovation of a new approach was required in the higher grades, this past training is thought to have been a greater advantage than in the more standard lower grade topics. Also, of equal importance was the fact that students receiving previous resource training in District 5 may have developed backgrounds which were responsible for the higher performances on the examinations.

The implications of the significantly better responses of the second grade and no significantly different response of the other grades on their tests are more easily discussed in the test x grade interactions. Second grade differences of performance in the grade x pre-test, grade x post-test and grade x test interactions suggest two contrasting cause and effect relationships. First, test level may have been too low for the grade level. The high performance on the pre-test x grade interaction and low achievement performance in the test x grade interaction supports this contention. Greater teacher familiarity with the subject of water may have provided a better teaching background resulting in better instruction; however, the pre-test and post-test response similarity would not support such a contention. Sixth grade performances in this interaction serve to reinforce the earlier position that the teacher's guide was not adequate for that subject. Compounding this problem, teacher training for the sixth grade level is such that it does not often provide the appropriate preparation for teaching minerals and oils.

Upper grade responses in the grade x test interaction suggest an overall balance was common to all units. Significantly better performance in grade 8 pre-tests may have reflected current increased general discussion of social problems outside of the classroom. Generally, the rather consistent responses indicate a uniform level of unit difficulty. This situation may also be a reflection of better teacher preparation in subject matter for the upper grades which results in greater consistency of teaching at the appropriate level for the grades tested.

Significant test x city interactions in grades 7 through 9 further support the earlier indication that the training of more teachers of District 5 in conservation workshops favorably influenced student responses. Students from District 5 had higher pre-test scores which appear to have resulted from better subject background gained earlier at lower grade levels. Environment may have also been a factor. A large majority of students in District 5 may be familiar with conservation because of their family ties with a soil and water conservation district. The post-test x city and pre-test and post-test differences x city interactions indicate teacher performance and environmental background are closely related to the high performance of District 5 students.

Concerning the city x grade interactions, it is interesting to note the consistency of no significant differences in five lower grades in the five districts. With the exception of grade 4 in District 5 and grade 6 in District 3 no significant difference of response within a city and between grades 1, 2, 4, 5, and 6 existed. In the upper grades, grade 8 responses indicated a uniform performance in all cities.

Ranking of cities from highest to lowest on the basis of grade responses is not a sharply delineated ordination. In the lower grades Districts 5 and 4 are closely clumped at the top and Districts 2 and 3 are lowest. At the upper grade levels District 5 is alone at the top, Districts 2 and 1 in the middle and District 3 the lowest. Characteristics of District 5 discussed earlier are thought responsible for the consistently high student performance. The reasons for the consistently low performance in District 3 is not known. One might speculate that the more urban nature of the district and possibly the nature of teacher and student background or interest may be related to this performanc.

In general, the outcome of this statistical analysis indicates that, with exception of grade 6, the material presented was at an appropriate level of difficulty for the respective grades. This generalization involves the consideration that deviations in the teacher's guides from the normal level of difficulty for each grade may easily have been offset by the teacher readjusting the material to the appropriate level for their students. Student performance can be expected to vary according to the quality of teaching. The latter is a reflection of the quality of the teacher training and the materials available for the presentation of the topics. Cultural backgrounds of the students may also modify the student performance. An accurate measure of this factor is practically impossible in Wyoming in those school districts having reasonable student population sizes for study purposes. Cultural characterization is difficult to develop and where one attribute is identifiable in one school, it may not be in all the others. Rural students are intermingled with students living in towns and sedentary town students are intermingled with students from transient families, etc. Considering these problems, the general consistency in test performances between grades and between different subjects is rather remarkable.

CONCLUSIONS AND RECOMMENDATIONS

Sequential conservation core units presented in the newly developed teacher's guides for grades 1 through 9 were successful, except for Grade 6. The latter unit on minerals and oil will require rewriting. Except for the general weakness of the minerals and oil unit, the teacher's guides appeared to be very useful. Low teacher ratings on the teacher's reference sections appear to emphasize the necessity of increased fiscal support for library references and teaching aids in the area of natural resource conservation. The most basic and minimal resource books were absent in the majority of the school libraries.

A general concensus of the teacher's responses, indicated that the sequential teacher's guides would provide a common organization focal point for a stimulating and effective method of teaching conservation principles in the impressionable years from grade 1 through 9. No less than 2 weeks and preferably 3 or 4 weeks appeared to be the most desirable length of time required to present each unit.

Statistical evaluations of student pre-test and post-test responses indicated that the teachers use of the guides and their classroom presentations were successful in creating an awareness of and stimulating student interest in conservation problems. Consistent student test performances in all school districts and in all grades, except Grade 6, would indicate that the unit materials are at an appropriate grade level of difficulty.

The importance of including conservation in teacher training was emphasized by student test responses. Student test performances were consistently higher in the school district where a greater majority of the teachers were known to have had workshop or formal conservation training. Cultural background of the student apparently had little detectable influence on the student's performance and receptivity.

Results of this study support the usefulness of the sequential resource unit approach to both the teacher and the student. A rapidly deteriorating environment stresses the urgency to implement this conservation program in grades 1 through 9 as rapidly as possible.

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APPENDIX A

Analysis of Variance Effect Difference and Effect Significance

Appendix A

Table 1. Contrast of sex effects in grades 1 through 6 using Tukey's method of multiple comparisons, with a critical value of 6.92.

Sex	$\bar{x}_{ij}$	$\bar{x}_{ij} - \bar{x}_{ij'}$
Boys	66.56	1.46
Girls	65.10	

Table 2. Contrast of city effects in grades 1 through 6 using Tukey's method of multiple comparisons, with a critical value of 13.38.

City	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i4}$	$\bar{x}_{ij}-\bar{x}_{i2}$	$\bar{x}_{ij}-\bar{x}_{i3}$	$\bar{x}_{ij}-\bar{x}_{i5}$
1	68.67	4.50	4.33	3.67	1.67
5	67.00	2.83	2.66	2.00	
3	65.00	0.83	0.66		
2	64.34	0.17			
4	64.17				

Table 3. Contrast of city effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 5.82

City	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i3}$	$\bar{x}_{ij}-\bar{x}_{i2}$	$\bar{x}_{ij}-\bar{x}_{i1}$
5	69.03	10.50	6.08	5.51
1	63.52	4.99	0.57	
2	62.95	4.42		
3	58.53			

Table 4. Contrast of grade effects in grades 1 through 6 using Tukey's method of multiple comparisons, with a critical value of 13.96.

Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i4}$	$\bar{x}_{ij}-\bar{x}_{i3}$	$\bar{x}_{ij}-\bar{x}_{i6}$	$\bar{x}_{ij}-\bar{x}_{i1}$	$\bar{x}_{ij}-\bar{x}_{i5}$
2	75.42	15.26	14.49	13.30	10.08	4.20
5	71.02	10.86	10.09	8.90	5.68	
1	65.34	5.18	4.41	3.22		
6	62.12	1.96	1.19			
3	60.93	0.77				
4	60.16					

Table 5. Contrast of pre-test x grade in grades 1 through 6 using Tukey's method of multiple comparisons, with a critical value of 13.96.

Ore-test x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i3}$	$\bar{x}_{ij}-\bar{x}_{i4}$	$\bar{x}_{ij}-\bar{x}_{i1}$	$\bar{x}_{ij}-\bar{x}_{i6}$	$\bar{x}_{ij}-\bar{x}_{i5}$
1-2	68.06	20.93	18.52	15.90	13.08	11.92
1-5	56.14	9.01	6.60	3.98	1.16	
1-6	54.98	7.85	5.44	2.82		
1-1	52.16	5.03	2.62			
1-4	49.54	2.41				
1-3	47.13					

Table 6. Contrast of post-test x grade in grades 1 through 6 using Tukey's method of multiple comparisons, with a critical value of 13.96.

Post-test x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i6}$	$\bar{x}_{ij}-\bar{x}_{i4}$	$\bar{x}_{ij}-\bar{x}_{i3}$	$\bar{x}_{ij}-\bar{x}_{i1}$	$\bar{x}_{ij}-\bar{x}_{i2}$
2-5	85.91	16.65	15.12	11.17	7.40	3.13
2-2	82.78	13.52	11.99	8.04	4.27	
2-1	78.51	9.25	7.72	4.07		
2-3	74.74	5.48	3.95			
2-4	70.79	1.53				
2-6	69.26					

Table 7. Contrast of test x grade effects in grades 1 through 6 using Tukey's method of multiple comparisons, with a critical value of 13.96.

Test x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i6}$	$\bar{x}_{ij}-\bar{x}_{i2}$	$\bar{x}_{ij}-\bar{x}_{i4}$	$\bar{x}_{ij}-\bar{x}_{i1}$	$\bar{x}_{ij}-\bar{x}_{i3}$
D-5	29.77	15.49	15.05	8.52	3.42	2.16
D-3	27.61	13.33	12.89	6.36	1.26	
D-1	26.35	12.07	11.63	5.10		
D-4	21.25	6.97	6.53			
D-2	14.72	0.44				
D-6	14.28					

Table 8. Contrast of grade effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 5.82.

Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i9}$	$\bar{x}_{ij}-\bar{x}_{i7}$
8	65.47	4.70	1.07
7	64.30	3.55	
9	60.75		

Table 9. Contrast of pre-test x grade effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 6.00.

Pre-test x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i9}$	$\bar{x}_{ij}-\bar{x}_{i7}$
1-8	57.90	8.43	5.56
1-7	52.34	2.87	
1-9	49.47		

Table 10. Contrast of post-test x grade effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 6.00.

Post-test x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i9}$	$\bar{x}_{ij}-\bar{x}_{i8}$
2-7	76.26	4.23	3.23
2-8	73.03	1.00	
2-9	72.03		

Table 11. Contrast of test x grade effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 6.00.

Test x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i8}$	$\bar{x}_{ij}-\bar{x}_{i9}$
7	23.92	8.79	1.36
9	22.56	7.43	
8	15.13		

Table 12. Contrast of pre-test x city effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 6.52.

Pre-test x City	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i2}$	$\bar{x}_{ij}-\bar{x}_{i1}$	$\bar{x}_{ij}-\bar{x}_{i3}$
1-5	59.28	8.28	8.20	7.68
1-3	51.60	0.60	0.52	
1-1	51.08	0.08		
1-2	51.00			

Table 13. Contrast of post-test x city effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 6.52.

Post-test x City	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i3}$	$\bar{x}_{ij}-\bar{x}_{i2}$	$\bar{x}_{ij}-\bar{x}_{i1}$
2-5	78.78	13.32	3.88	2.82
2-1	75.96	10.50	1.06	
2-2	74.90	9.44		
2-3	65.46			

Table 14. Contrast of test x city effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 6.52.

Test x City	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{i3}$	$\bar{x}_{ij}-\bar{x}_{i5}$	$\bar{x}_{ij}-\bar{x}_{i2}$
1	24.88	11.02	5.38	0.97
2	23.91	10.05	4.41	
5	19.50	5.64		
3	13.86			

Table 15. Contrasts of city x grade effects in grades 1 through 6 using Tukey's Method of multiple comparisons, with a critical value of 16.85.

City x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{129}$	$\bar{x}_{ij}-\bar{x}_{128}$	$\bar{x}_{ij}-\bar{x}_{127}$	$\bar{x}_{ij}-\bar{x}_{126}$	$\bar{x}_{ij}-\bar{x}_{125}$	$\bar{x}_{ij}-\bar{x}_{124}$	$\bar{x}_{ij}-\bar{x}_{123}$	$\bar{x}_{ij}-\bar{x}_{122}$	$\bar{x}_{ij}-\bar{x}_{121}$	$\bar{x}_{ij}-\bar{x}_{120}$	$\bar{x}_{ij}-\bar{x}_{119}$	$\bar{x}_{ij}-\bar{x}_{118}$
1-2	78.86	26.86	24.11	22.04	21.91	20.34	20.09	20.07	17.34	17.14	17.12	17.09	16.36
5-2	78.46	26.50	23.75	21.68	21.55	19.98	19.73	19.71	16.98	16.78	16.76	16.73	
1-5	77.41	25.45	22.70	20.63	20.50	18.98	18.68	19.66	15.93				
3-2	75.61	23.65	20.80	18.83	18.70	17.13	16.88	16.86					
4-2	73.48	21.52	18.77	16.70	16.50	15.00	16.75	14.73					
5-3	72.62	20.66	17.91										
2-1	72.16	20.20	17.45										
2-2	70.73	18.77	16.02										
2-5	70.68	18.72											
4-5	69.41	17.45											
5-5	68.98	17.02											
1-6	68.89	16.93											
3-5	68.64	16.68											
5-1	67.45	15.49											
4-1	64.28												
3-4	64.12												
4-6	63.98												
1-1	63.85												
5-6	62.46												
4-1	61.73												
3-3	61.70												
4-4	61.68												
3-1	61.48												
2-4	58.75												
1-3	58.73												
3-6	58.48												
2-3	56.91												
2-6	56.78												
4-3	54.71												
5-4	51.96												

Table 16. Contrast of city x grade effects in grades 7 through 9 using Tukey's method of multiple comparisons, with a critical value of 8.15.

City x Grade	$\bar{x}_{ij}$	$\bar{x}_{ij}-\bar{x}_{112}$	$\bar{x}_{ij}-\bar{x}_{111}$	$\bar{x}_{ij}-\bar{x}_{110}$	$\bar{x}_{ij}-\bar{x}_{19}$	$\bar{x}_{ij}-\bar{x}_{18}$	$\bar{x}_{ij}-\bar{x}_{17}$
2-7	71.19	18.53	16.75	13.95	9.72	8.24	7.28
5-8	70.01	17.35	15.57	12.77	8.54	7.06	6.10
5-9	69.78	17.12	15.34	12.54	8.31	6.83	5.87
5-7	67.31	14.65	12.87	10.07	5.84	4.36	3.40
1-9	66.13	13.47	11.69	8.89	4.66	3.18	2.22
2-8	65.01	12.35	10.57	7.77	3.54	2.06	1.10
3-8	63.91	11.25	9.47	6.67	2.44	0.96	
1-8	62.95	10.29	8.51	5.71	1.48		
1-7	61.47	8.81	7.03	4.23			
3-7	57.24	4.58	2.80				
3-9	54.44	1.78					
2-9	52.66						

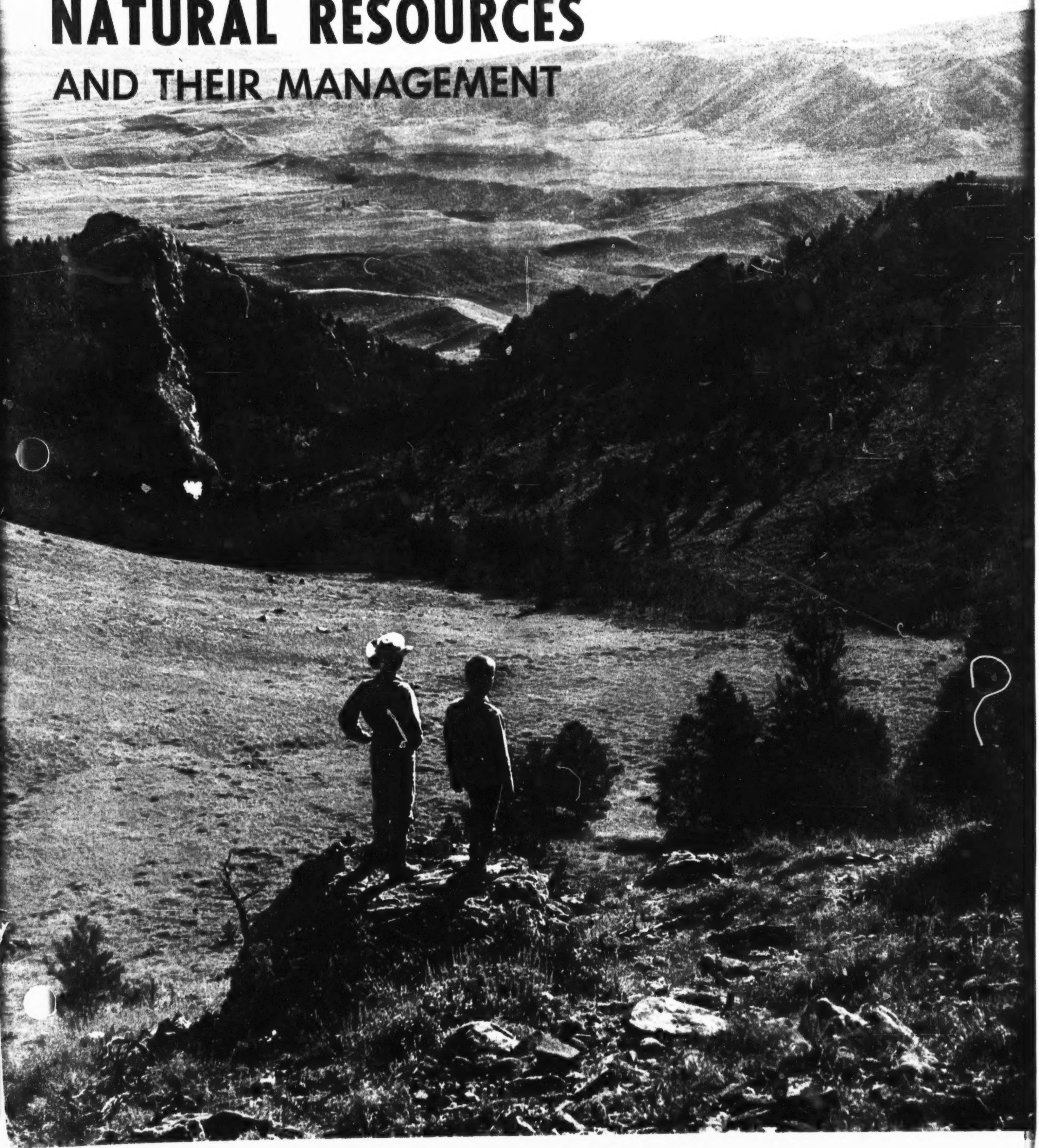
APPENDIX B

Teaching Guides For Integrated Natural Resource Core Units

Grades 1 through 9

WYOMING'S NATURAL RESOURCES

AND THEIR MANAGEMENT



Conservation Pledge

I GIVE MY
PLEDGE AS AN AMERICAN
TO SAVE AND FAITHFULLY TO
DEFEND FROM WASTE THE
NATURAL RESOURCES OF
MY COUNTRY - ITS SOIL
AND MINERALS, ITS
FORESTS, WATERS
AND WILDLIFE

EDITORS

H. M. Hennebry
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WYOMING'S NATURAL RESOURCES
AND THEIR MANAGEMENT

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Foreword

WYOMING is a land all its own, a blend of the old and new, a contrast of the desolate and the beautiful, the rich and the poor. As a state Wyoming has many potentials. The intelligent realization of these potentials will depend upon many people and their ability to utilize resources today while exercising a conscientious eye for the future.

Development—the gradual utilization of Wyoming's natural resources—must preclude selfish motives of individuals and private interests. The need for a general awareness has always been basic in the management and utilization of any natural resource. This need will become even more basic as management and exploitation become more intensive.

Wyoming resources must serve many people, now and in generations to come. Their use and ultimate utilization must provide the materials necessary for the implements of modern day life and, beyond this, the economic base for our livelihood. The aesthetic values, the soul-nourishing spiritual qualities, must also receive a priority in the utilization scale. Because these more nebulous qualities have no monetary value they are often neglected. Once neglected they can never be restored.

The editors and authors of this publication have endeavored to provide, in comprehensive form, an inventory and insight into the management of Wyoming's natural resources for the teachers of Wyoming that they might integrate this knowledge into their curriculums. Our resources are the most basic factor in life and our level of living is directly related to their availability. The student's realization of this fact will enhance the resource management of the future.

The excellence of the material contained in this publication has taken it beyond the original goal of being a teacher's manual. It is the most current and complete publication dealing with Wyoming resources. The use of intelligent and understandable terminology gives the layman an opportunity for insight into our State's resources and their use. The completeness of the publication makes it a valuable reference work for the professional.

James B. White

James B. White
Director
Wyoming Game and Fish Department

Preface

A need for a booklet summarizing natural resources use and management in Wyoming has long been apparent to teachers, public officials, and conservationists. However, this booklet cannot be considered to be the final word; changes are presently occurring and will occur in the future regarding policy and use of these resources. Each chapter is rather complete in itself, but bound together the chapters form an integrated picture of Wyoming's resources and their use. If further information is desired on a specific topic, the literature cited and suggested references can lead to an in-depth study on that topic.

While no attempt was made by the individual authors to discuss Wyoming's natural resources in relation to National policies, problems and difficulties common to Wyoming are frequently experienced by other states and countries. In today's highly industrialized society the consumer is far removed from the natural resources and natural resource producer. Because his everyday activities are not closely allied to those resources, the individual citizen feels he can do little to alter or influence natural resource management policies. This results in the average citizen looking upon natural resource problems with very detached attitudes. For example, the Wyoming urban dweller buying tomatoes raised on newly drained wetlands in southern Florida is not aware of the undesirable soil loss, freshwater loss, and land abuse that resulted from the production of the short term truck garden product. Likewise, the rancher and the farmer enjoy clean, fresh air everyday and are unable to grasp the serious threat of air pollution spreading out from urban industrial areas and transportation complexes. Both urban and rural inhabitants purchase large amounts of paper products oblivious to the problems involved in growing the trees that produced the paper, or the difficulties of protecting the soil and watersheds while harvesting the pulp trees. They are also generally unaware of difficulties in maintaining water quality of the rivers and lakes adjacent to the pulp mills. These difficulties plus the insatiable drive to annually increase the Nation's gross national product is permitting excessive waste of our resources, many of which are becoming alarmingly short in both quantity and quality. Obsolescence of manufactured goods preoccupies our public conscience and nothing is more obsolete than the status quo. No other nation in the world faces this problem to the degree which we do here in the United States.

By continually sustaining the economic growth rate and production output, by compelling consumers into satisfying wants they did not know they had, by discarding useful articles because they are old, or by replacing equipment made obsolete through controlled inferiority in manufacturing, we are placing excessive demands on raw materials thus rapidly depleting our resources at an alarming rate. The United States alone, since World War I, has used more minerals and metals than the total used throughout the world in all of the preceeding centuries. During World War II we became a deficit nation for raw materials. For example, the present United States growth demands require consumption of more than 50 percent of the world's petroleum and 90 percent of its natural gas. Further, the United States, with only 6 percent of the world's population, produces 16 percent of the world's food supply but its citizens eat 72 percent more (4,000 cal./person/day) than the minimum food requirement (2800 cal./person/day) and still do not consume all we grow. This high standard of living is taken for granted but the lessons of history are ever with us; a nation's resources are linked to its production capability which in turn determines its economic wealth. Each individual must realize that the resources of a nation are a measure of its wealth and its capability to maintain its culture. Therefore, as individual producers and consumers we must become more aware of the raw materials required to provide our high standard of living, and become more informed about the basic resource supplies presently available and the projected outlook for future needs in order to wisely shape future public policy.

The many sizeable technical advancements have encouraged man to forget that he is still tightly bound to his environment. The very fact that man has survived in an environment modified by technical advancements does not necessarily mean that such advancements are well planned, rational, or even desirable. Every individual who prizes his freedom has an obligation to learn what is going on around him and to become familiar with the trends, processes, and management problems of our natural resources and their relation to survival of a free society. What goes on in governmental circles is a reflection of the kind of people living in every town and village of our nation. To this end it is hoped that this publication will serve as a stimulus for each Wyoming resident to become better informed about the importance of these resources, not only to the Nation and Wyoming but to his own welfare.

H. M. Hennebry
K. L. Diem

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Physical Features and Geology of Wyoming

S. H. KNIGHT[1]

Professor Emeritus

Wyoming is an area of varied relief about two-thirds of which lies east of the Continental Divide and is drained by tributaries to the Missouri River. The one-third lying west of the divide is drained in large part by the Green River which is tributary to the Colorado River. A lesser portion (SW Yellowstone Park, Jackson Hole, and Gros Ventre Mountains) drains into the Snake River which is tributary to the Columbia River. The Continental Divide splits south of South Pass and the two branches which join south of Rawlins enclose an area of some 3,000 square miles with interior drainage (the Great Divide Basin). The vertical displacement of elevation on the Continental Divide is nearly 7,000 feet.

Wyoming is characterized by bold mountain ranges separated by broad, relatively flat-floored basins (Fig. 1). The southern mountain ranges (Laramie, Medicine Bow, and Sierra Madre) constitute the northern end of the Southern Rocky Mountain Physiographic Province. The mountains occupying the northern and western portions of the state are part of the Middle Rocky Mountain Province (Fenneman, 1931).

Wyoming is bounded on the south by the 41st parallel and on the north by the 45th parallel. The northern boundary is, therefore, halfway between the Equator and the North Pole. The east and west boundaries lie near the 104th and 111th meridians. When Wyoming was created the east boundary was on the 27th meridian west of Washington. The meridians from Greenwich, now in use, lie some three miles east of the Washington meridians.

Wyoming has an areal extent of 97,914 square miles and ranks 9th in size of the 50 states. The length of the southern boundary is 367 and a fraction miles; the western boundary is 227 and a fraction miles. It is the second highest state with an approximate mean altitude of 6,700 feet. Colorado has an approximate altitude of 6,800 feet. The highest point is Gannet Peak (elevation 13,785) in the Wind River Mountains and the lowest point (elevation 3,100 feet) is on the Belle Fourche River where it crosses the Wyoming-South Dakota boundary. The above figures on area and elevations are taken from the U. S. Geological Survey Bulletin No. 817.

LAND FORMS

Land forms evolve in response to (1) the character and position of the rocks of which they are made, (2) the forces which are brought to bear upon the rocks and (3) the time the forces have been in operation. Rocks vary greatly in their ability to withstand the forces which act upon them. Some are relatively resistant, others are much less resistant. Forces may be both constructive and destructive. Mountains rise in response to movements in the Earth's crust and are destroyed by erosion. Land forms may be young, mature or old, depending upon the time the forces acting upon them have been in operation. They may be rejuvenated and pass through another life cycle. Land form evolution may be compared to the creation of a statue when a sculptor carves

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[1] Professor Emeritus, Department of Geology, University of Wyoming.

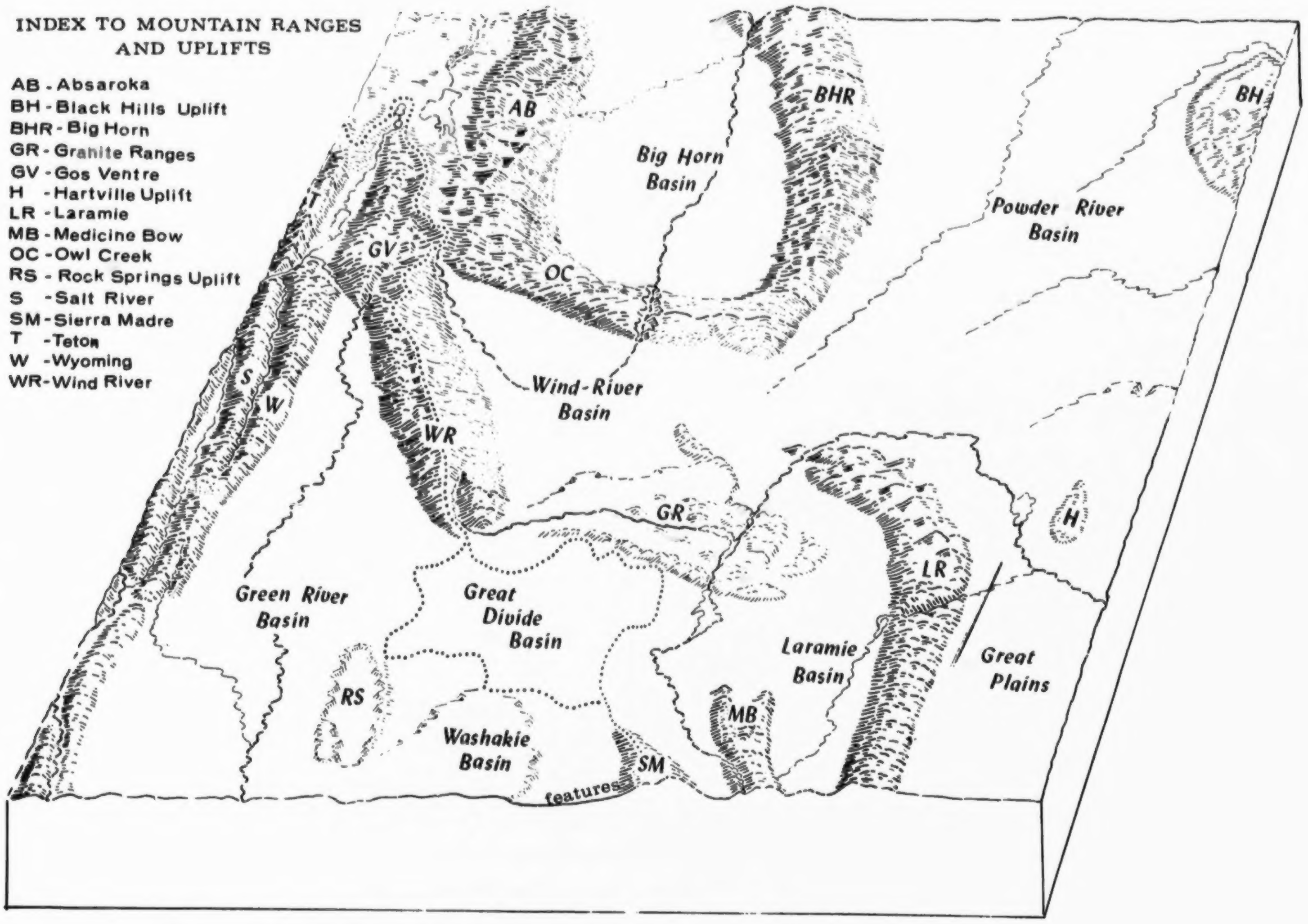
INDEX TO MOUNTAIN RANGES AND UPLIFTS
AB - Absaroka
BH - Black Hills Uplift
BHR - Big Horn
GR - Granite Ranges
GV - Gos Ventre
H - Hartville Uplift
LR - Laramie
MB - Medicine Bow
OC - Owl Creek
RS - Rock Springs Uplift
S - Salt River
SM - Sierra Madre
T - Teton
W - Wyoming
WR - Wind River
AB
BHR
BH
Big Horn Basin
Powder River Basin
GV
OC
T
S
W
Wind-River Basin
WR
GR
H
LR
Green River Basin
Great Divide Basin
Laramie Basin
Great Plains
RS
MB
Washakie Basin
SM
features

Fig. 1. Diagram of the major relief of Wyoming.

a distinctive form by the partial destruction of a block of marble. Fig. 2 is a generalized diagram of the principal land forms of Wyoming showing their character and position in relation to the underlying rocks and to each other. There are variations. For example, where the mountain fronts are faulted (movements along fracture zones) instead of folded as shown in the diagram the hogback zone is absent.

The following are brief descriptions of the land forms shown in Fig. 2.

Axial remnants. These remnants lie on or near the axis of the mountain folds and they are the relics of a previous cycle of erosion. They are conspicuous features of the higher ranges. They were glaciated during the Pleistocene Epoch (discussed under Geology) and exhibit land forms characteristic of the destructive effects of alpine glaciation (U-shaped valleys, cirques, rock-cut basins, cols (gaps), and pyramidal peaks). The Snowy Range in the Medicine Bow Mountains is an axial remnant.

High-level erosion surfaces. These surfaces, now extensively dissected by mature canyons, slope from the bases of the axial remnants (where present) to the crests of the mountain fronts. The canyons were cut by streams and later modified by glaciers. The equal levels of the interstream divides are a conspicuous feature of these surfaces. Good examples may be observed along the west side of the Wind River and Medicine Bow Mountains.

Mountain fronts. The mountain fronts which rise precipitously from their bases are the results of (1) the stripping of the sedimentary layers from the more resistant rocks of the mountain cores along the flanks of folds or (2) the results of faulting. In both instances the mountains owe their present relief to the resistant character of the rocks which make up their cores. While this is true of most of the mountain ranges there are exceptions. The Absaroka Range is made up of volcanic rocks and the Wyoming and Salt River Ranges are made up of faulted sedimentary rocks. The most conspicuous mountain front is the east face of the Tetons which rises 7000 feet in an

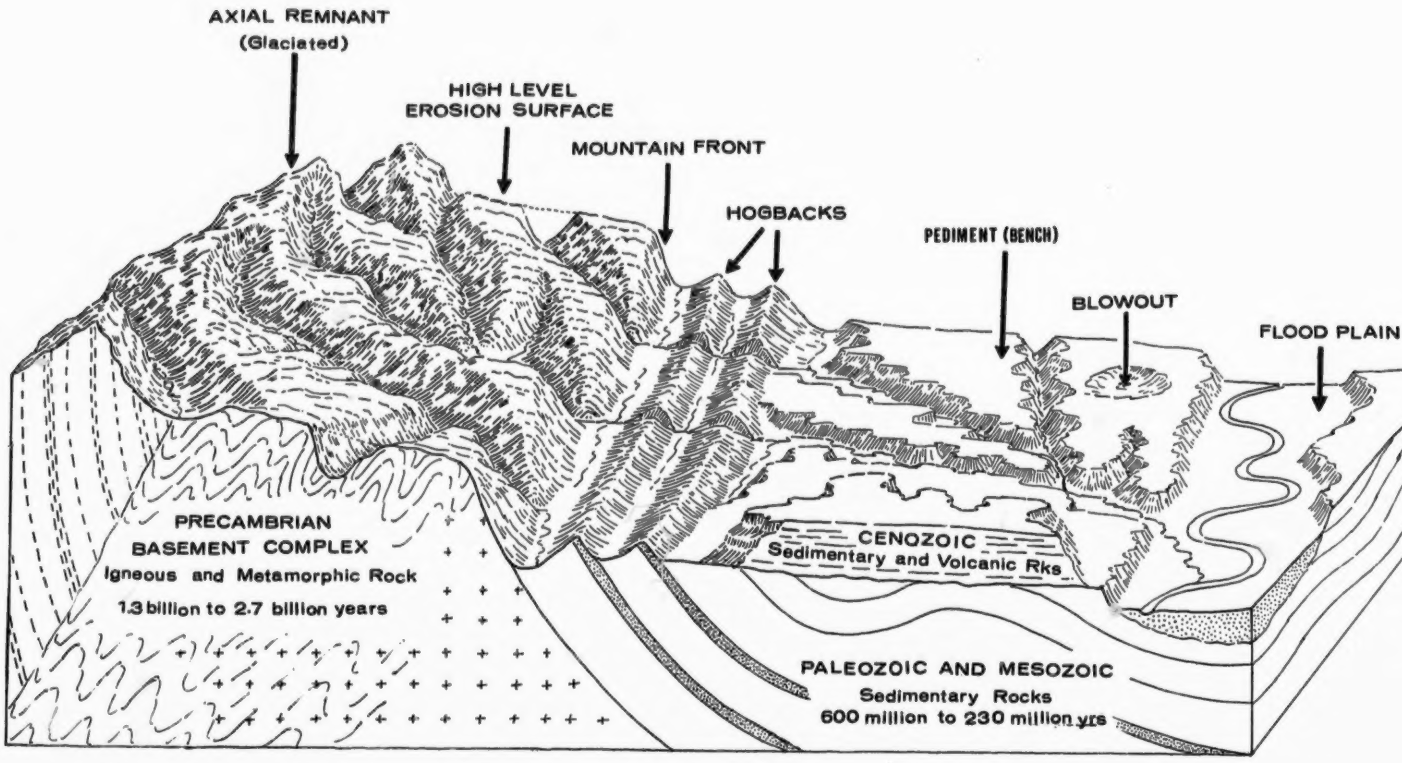

Fig. 2. Generalized diagram of principal land forms, their relations to underlying rocks and to each other.

equal distance horizontally. Here comparatively recent movements along a fracture zone have elevated the range with respect to Jackson Hole.

The hogback zone. Hogbacks are symmetrical ridges which parallel the flanks of mountain folds. They are separated from the mountain front and from each other by shallow valleys. They result from differential erosion where (1) the sedimentary succession has been tilted to moderately high angles and (2) where a resistant bed lies between two beds which are more readily destroyed. Hogbacks vary in height from 100 to several hundred feet. Frequently they parallel the mountain fronts for many miles. Their continuity is broken by transverse, steep-walled water gaps cut by streams draining from adjacent highlands. The hogback zone is absent where the mountain is faulted.

A hogback zone is well developed along the northeast flank of the Wind River Range. Access roads into the mountains frequently pass through the water gaps which cut across the hogbacks.

Pediment surfaces. A widespread and conspicuous land form lying between the hogback zone and the river flood plains are pediment surfaces which are frequently referred to as benches. These surfaces are erosional features which cut across the underlying rocks. They are capped, however, with a thin veneer of gravel, sand or soil. These surfaces slope basinward and were formed at different levels and at different times. They have been dissected to varying degrees. Some are remnants only a few acres in extent while others cover areas of tens of square miles. They were formed in their present positions and are believed to reflect cyclic climatic changes during the Pleistocene Epoch.

Blowouts. Windblown depressions are numerous and striking features. They originated when and where the following conditions prevailed: 1) the underlying rocks were fine textured shales or sandstones, 2) a protective cover of cobbles or gravel was absent, and 3) they were formed at a time when the present cover of vegetation was less effective in protecting the exposed rock particles from wind transport. The drainage in these depressions forms ponds. During the dry season the water in these ponds evaporates leaving an incrustation of salts (chiefly alkali). Blowouts vary greatly in size and in depth. Some may cover only a few acres while others may be 2 miles wide and 10 miles long and are 200 or more feet deep. The Big Hollow 4 miles west of Laramie is one of the larger blowouts measuring 9 miles long, 2 miles wide and 200 feet deep.

Flood plains. Rivers aggrade (build up) or degrade (tear down) their courses. Aggraded flood plains are common features which vary in width from place to place. The depth of the alluvial fill varies from a few feet to 100 feet or more.

Badlands. The name badlands is applied to the intricate maze of narrow ravines separated by sharp ridge crests, pinnacles and buttes. These intricately eroded surfaces are devoid of vegetation. Badlands occur in some places where Tertiary rocks are being eroded as seen at Hell's Half Acre west of Casper near Waltman.

GEOLOGY

The Earth is believed to be from 4.5 to 5 billion years old. The history of the Earth, recorded in the rocks open to observation, goes back in time more than 3 billion years. Radiometric dating (A. Hills, *et al.*, 1965, and W. A. Bassett and B. J. Giletti, 1963) tells us the oldest rocks of Wyoming thus far dated are not less than 2.7 billion years old. The historical record from this remote beginning is not complete as there are "lost intervals" when the region stood above base level as it does today, and was subjected to erosion; the only record is the passing of time. Wyoming shares this with other areas; nowhere on the continents at least, is there a continuous record of the history of the Earth. The existing record as preserved in this state has been studied for a century but it is so vast that much remains to be learned. However, rocks representative of the five great Eras (major divisions of Geologic Time) are present. There are few areas of comparable size where the geologic history of the Earth, from its remote beginning to the present, is as well documented.

For the purposes of this chapter the rocks of Wyoming have been divided into three major groups. The oldest group makes up the Basement Complex. The second older group is the Older Sedimentary Succession. The third and youngest group is the Younger Sedimentary Succession and Associated Volcanic Rocks. The age, character, occurrence and the life of each of these groups is briefly discussed. The changing environments which characterized the area throughout its known geologic history are mentioned.

The Basement Complex

The Archeozoic Era (3.3 billion to 2.45 billion years B.P. [2]) and the Proterozoic Era (2.45 billion to 600 million years B.P.).

The following description of the Basement Complex is based largely on the research of Professor R. S. Houston, who, with the aid of graduate students, has made extensive studies of these rocks in recent years.[3]

Basement Complex rocks make up the great bulk of most of the mountain ranges. They occur in the Big Horn, Gros Ventre, Laramie, Medicine Bow, Sierra Madre, Teton, and Wind River Mountains, also in the Granite Ranges and the Hartville Uplift. Radiometric age determinations give the age range of these rocks in Wyoming from 2.7 billion plus to 1.35 billion years B.P.

Archeozoic rocks. The oldest known rocks were originally a vast succession of sands, silts and lime muds interbedded with numerous lava flows. The sands and silts were derived from and deposited upon a more ancient unknown crust. The lime muds may have been the remains of lime secreting organisms. This cannot be proved, in that all evidence of organic structure, if it existed, has been destroyed. This sedimentary rock and lava succession was invaded by magma (liquid and gaseous material) of different composition at different times during which much granite was formed. These rocks were subjected to intensive crustal stresses which folded and crushed them into complex patterns. Heat, pressure and chemical change metamorphosed these rocks into a variety of quartzites, marbles, slates, schists and gneisses. Today these rocks make up distorted and crumpled masses of highly metamorphic rocks and a variety of intrusive rocks which are exposed as irregular masses in the cores of several mountain ranges such as the Medicine Bow Mountains. No rocks of the primitive crust upon which the Archeozoic rocks were deposited are known to have survived.

Proterozoic rocks. The next major event following the formation of the Archeozoic rocks was a profound period of erosion during which the surface was reduced to one of low relief. This is one of the "lost intervals." Following this erosion interval new highlands were formed. The location of these highlands cannot be determined owing to the fragmentary nature of the record. These mountains were attacked by erosion, and a vast amount of rock debris derived from the highlands was deposited over an area of unknown extent. The area included southeastern Wyoming and beyond. Thus there came into being a vast new succession of sediments and volcanic outpourings. This succession has an aggregate thickness of not less than 30,000 feet. The rocks consisted of thick beds of sand, silt, lava flows, possibly glacial deposits (Blackwelder, 1926) and limestones. The limestones are of special interest in that they occur as heads and reefs (Knight and Keefer, 1966) in which are preserved the remains of lime secreting organisms (algae) which lived not less than 1.7 billion years ago.[4] Algal reefs are well exposed in the Medicine Bow Mountains. Fig. 3 represents a stage in the de-

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[2] B. P. stands for Before the Present.

[3] These studies which principally treat the Medicine Bow Mountains will appear in a forthcoming publication of the Wyoming Geological Survey.

[4] Dr. S. H. Knight is engaged in a study of these remains.

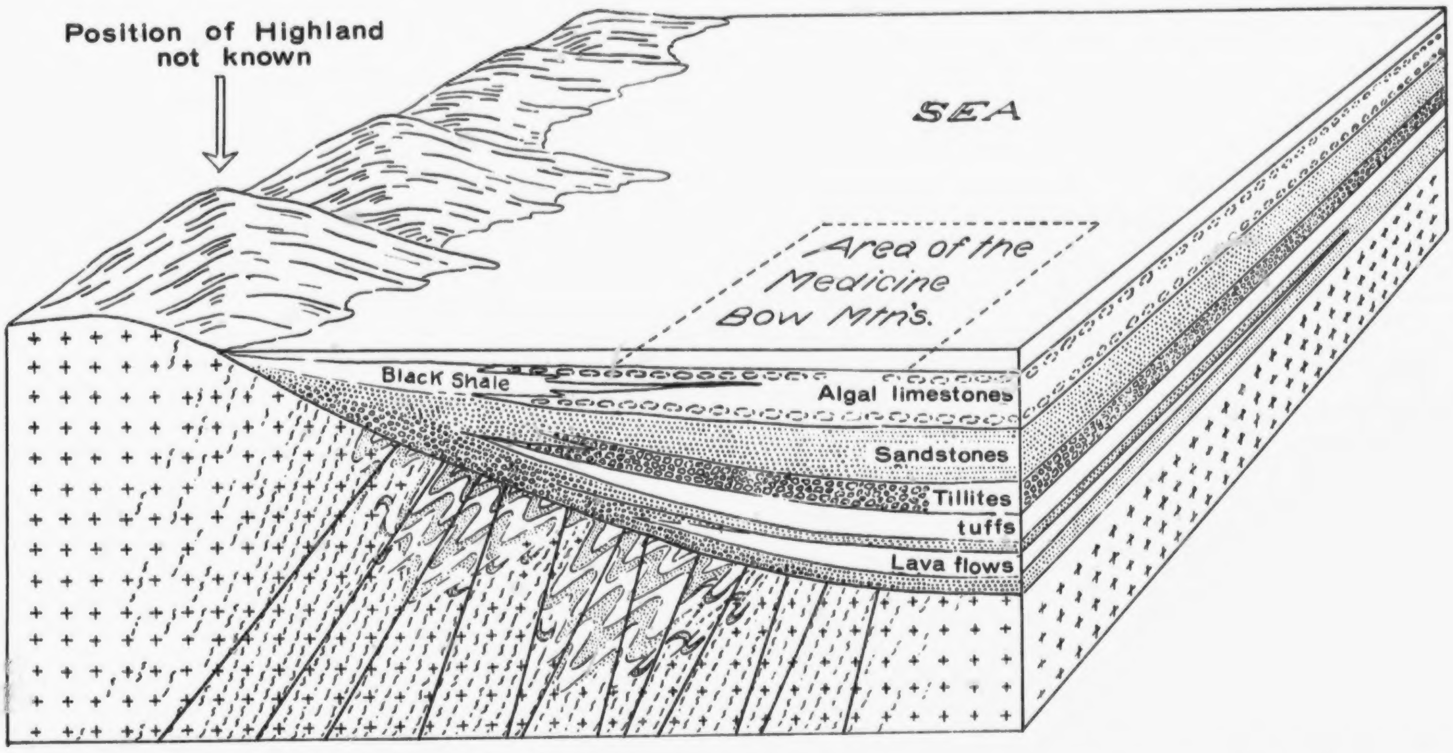

Fig. 3. Time 1.9 to 1.7 billion years. Deposition of 30,000 + feet of lava flows, tuffs, tillites, conglomerates, sandstones, black shales, and algal limestones.

velopment of the Proterozoic rocks. These rocks were intruded by magmas of different composition at different times and again much granite was formed. Another period of crustal movements folded and faulted these rocks although the folding was less severe than that which affected the older Archeozoic rocks.

The concluding event in the history of the Proterozoic was a profound erosion interval during which the surface was reduced to one of low relief.

The Older Sedimentary Succession

The Paleozoic Era (600 million to 230 million years B.P.) and the Mesozoic Era (230 million to 70 million years B.P.).

The Paleozoic Era. The Paleozoic Era is divided into the following time periods (the figures are in millions of years B.P.): Cambrian (600-500), Ordovician (500-425), Silurian (425-405), Devonian (405-345), Mississippian (345-320), Pennsylvanian (320-280) and Permian (280-230). With the exception of the Silurian[5] all periods are represented in Wyoming by one or more formations.

Throughout most of Paleozoic time Wyoming was a region of low relief which was alternately depressed and elevated above the sea. The surface was a broad shelf which was lower in the west and higher in the east. During the times this shelf was depressed beneath the sea, sediments consisting of sandstones, shales and limestones were deposited upon it. These deposits are much thicker in the western portion where they present a more continuous record of Paleozoic time. The deposits, for the most part, thin out and disappear when traced from west to east. Only rocks of Pennsylvanian and Permian age are present in the southeast and are well exposed on the west flank of the Laramie Range east of Laramie.[6]

In late Paleozoic time highlands extended from Colorado into south-central Wyoming. These highlands are known as the Ancestral Rockies. During Pennsylvanian time, coarse textured rocks (conglomerate and arkose) from the highlands were deposited on an alluvial flood plain which flanked the highlands, while fine textured sediments were deposited in an adjacent sea which covered most of the state.

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[5] A recently discovered small remnant of limestone near the Colorado-Wyoming boundary, which contains fossils of Ordovician and Silurian age (J. Chronic and C. S. Ferris, 1963) supports the conclusion that the Silurian Sea may have covered Wyoming and that subsequent erosion removed the rocks which were deposited in this sea.

[6] For details on the occurrence of Paleozoic rocks in Wyoming see Thomas, 1949.

Fossil remains of a variety of invertebrates occur abundantly in Paleozoic rocks. Numerous species of trilobites, corals, brachiopods, pelecypods etc. occur. Some of the earliest evidence of vertebrate life (fragmentary fish remains) are found in rocks of Ordovician age. However, fish remains in rocks of Devonian age are better known.

The Mesozoic Era. The Mesozoic Era is divided into the following time periods (the figures are in millions of years B.P.): Triassic (230-180), Jurassic (180-135) and Cretaceous (135-65).

Rocks of Triassic, Jurassic and Cretaceous age are widespread throughout the state. They are extensively exposed in the hogback zone and on the basin floors. There is no great erosion interval between Paleozoic rocks and Mesozoic rocks.

Wyoming was again a lowland throughout Mesozoic time. The landscape was devoid of marked relief. The sea advanced and withdrew repeatedly; as the shoreline shifted both landward and seaward, various portions of the state were submerged from time to time. As the sea withdrew, low lying plains were left in its wake. Thus, there came into being an interfingering succession of marine and fresh water deposits.

Triassic Period: A thick succession of siltstones, shales and limestones was deposited over western Wyoming during Triassic time. In the central and eastern portions a brilliant red sequence of shales and siltstones was laid down. This sequence (Chugwater Formation) is conspicuous due to its color, and can be readily observed in the Redwall south of Barnum and in Red Canyon south of Lander. It is also noted for its lack of fossils. This formation is capped by a thin marine limestone throughout central Wyoming. A red sandstone with lenses of conglomerate terminates the Triassic rocks in the south.

Jurassic Period: The thickest and most complete occurrence of Jurassic rocks occurs in western Wyoming. Here these rocks aggregate 5000 feet thick. They thin progressively eastward and are only a few hundred feet thick over the eastern portion, where they consist of a marine formation (Sundance) and an overlying flood plain deposit (Morrison Formation). The Sundance Formation consists of sandstones and shales which were deposited in a shallow sea. It contains varied invertebrate faunas and remains of large marine reptiles. The Morrison Formation consists of shales and sandstones which were deposited on marshy flood plains of low relief drained by sluggish rivers. It is noted for its remains of the giant sauropod dinosaurs (Brontosaurus, Diplodocus etc.) and a host of other forms.

Cretaceous Period: During Cretaceous time there was deposited a vast succession of sandstones and shales which vary from 5000 to 15,000 feet thick. They are thicker in the south and west and thinner in the north and east. The source of this great volume of rock debris was from highlands lying to the west of the state. This rock debris was deposited in part on lowlands and in part beneath shallow seas. The lowlands were covered with dense growths of vegetation (modern plants were beginning to appear) which gave rise to abundant coal seams, some of which are exceptionally thick. Much oil was trapped in sandstones which was laid down in the sea.

The Cretaceous sea was replete with invertebrates. Cephalopods were in abundance, some of which grew to large size. The great reptilian horde of dinosaurs continued to live on the lowlands throughout the Cretaceous although they died out at the end of the period. The giant marine reptiles continued into the Cretaceous but disappeared before it closed.

The Laramide Revolution

Near the close of Cretaceous Period, and continuing into Cenozoic time some 70 million years ago, the outer shell of the Earth's crust underlying what is now the Rocky Mountain Region was subjected to great compressional forces. These forces folded and broke the crust. How deep the movements penetrated is a matter of conjecture. We know that the movements affected the entire rock succession described above. In the process of folding, the major up-folds gave birth to the mountain ranges and the down-folds became the basins. There are also many minor folds. In places the folding was so intense that fracture zones, which extend for many miles, developed along mountain flanks, and the mountains were thrust onto adjacent basins. The physical pattern of Wyoming, insofar as the size (surface area) and arrangement of mountains and basins is concerned, is due to the distribution of the folds and faults. The movements operated intermittently over a span of some millions of years. Both the mountain and basin folds have been greatly modified by erosion and later movements during the 60 odd million years since the compressional forces were stabilized.

The Younger Sedimentary Succession and Associated Volcanic Rocks

Cenozoic Era. The Cenozoic Era is divided into the Tertiary and Quaternary periods (65 million years B.P. to the present). The Tertiary period is divided into the following Epochs (the figures are in millions of years): Paleocene (65-58), Eocene (58-36), Oligocene (36-25), Miocene (25-13) and Pliocene (13 to about 1). The Quaternary is divided into the Pleistocene (about 1 million to 10,000 years) and Recent (10,000 years to the present).

Tertiary Period: Tertiary period was a time of great change. Folding and faulting due to compression continued into early Eocene time. As the mountains rose, they were eroded and vast quantities of rock debris poured into the basins. Volcanoes were intermittently active, notably in the region of the Yellowstone Plateau and the Absaroka Mountains and to a less extent in the Black Hills, the Rattlesnake Hills, and the Leucite Hills. Vast quantities of volcanic ejecta (lava and rock fragments) were laid down over large areas and blanketed much of the state at times. Crustal movements, which began relatively late and have continued (locally) to the present, rejuvenated the mountains and erosion has etched the region into its present relief.

The Tertiary has been called the "Age of Mammals". Preserved in these rocks is a remarkably complete fossil record of the development of the great mammalian class. Various stages in the evolution of a host of mammals from rodents to elephants, both living and extinct species, occur in these rocks. The vegetation, for the most part, was modern in aspect. Present day commercial grade uranium deposits are associated with these Tertiary rocks. The following are brief descriptions of Tertiary Epochs.

Paleocene Epoch. Mountain building movements were active. Large quantities of coarse textured rock debris was swept from the mountains and deposited as large alluvial fans flanking the mountains. These merged with alluvial plains dotted with coal-making swamps. A mild climate prevailed.

Eocene Epoch. Mountain building continued into early Eocene time when the mountains probably reached their greatest height with respect to the basin floors (Fig. 4). Again large quantities of rock debris accumulated in the basins. Volcanoes were active in the northwest. By the close of Eocene time the mountains had been greatly modified by the relentless attack of erosion. The axial remnants are vestiges of the former mountains. The high level erosion surfaces had been cut and dissected and some of the basin fill had been removed from the previously buried mountain fronts (S. H. Knight, 1953). During the time of basin filling, the drainage was impounded on the basin floors and large lakes were formed. The famous fish-bearing beds at Fossil, Wyoming and the large trona deposits of the Green River area were deposited in some of these lakes.

Oligocene Epoch. Oligocene rocks were deposited, in places at least, upon an erosional surface of considerable relief. The mountain fronts and valleys were again buried by thick accumula-

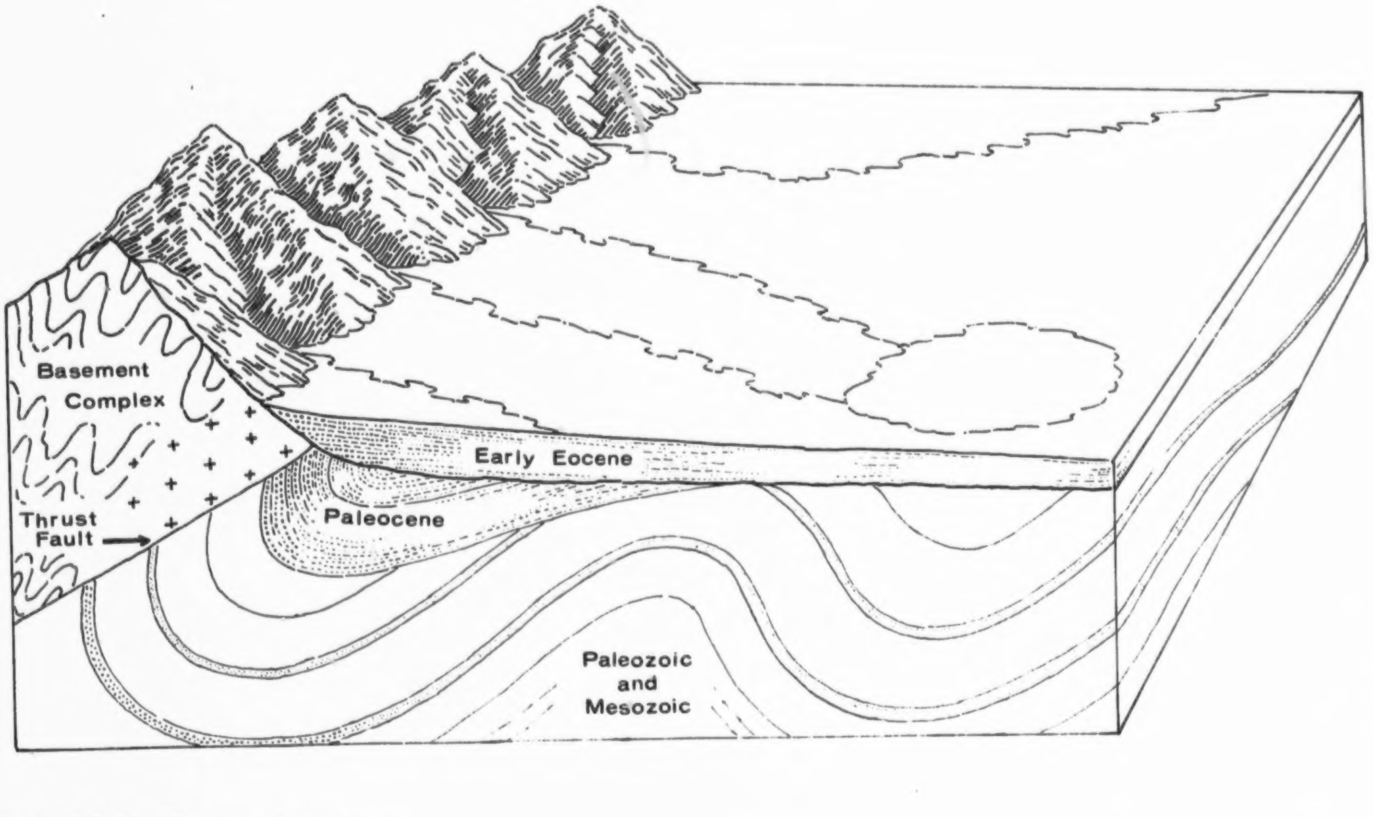

Fig. 4. Early Eocene landscape.

tions of volcanic ash and lesser amounts of material from the subdued highlands. Volcanoes were active.

Miocene Epoch. Miocene rocks which were once widespread have been largely removed by erosion. They are found on the Great Plains in the southeastern portion of the state and in more limited areas elsewhere. The rocks are composed of volcanic ash, much of it windblown, and coarser material. Remnants of these rocks lying on or close to the mountains contain boulders and cobbles.

Crustal movements began in late Miocene time, warped, faulted and uplifted the Miocene surface.

Pliocene Epoch. Rocks deposited during Pliocene time have been largely removed by erosion and are preserved only in limited areas. They are made up of sandstones, siltstones and algal limestones. Volcanic activity continued.

Quaternary Period: Pleistocene Epoch. The Pleistocene Epoch was a time of great climatic changes which are reflected in the erosional and depositional features. Three periods of glaciation have been recognized. Local ice caps covered the higher mountain regions during the times of glaciation; valley glaciers extended down the canyons to their mouths. Land forms characteristic of the destructive effects of alpine glaciation are conspicuous throughout the higher regions. Morainal dams impound many lakes. The basin floors are covered with surficial deposits of alluvium, sand dunes and windblown silt (loess), and landslides. The surface is etched with numerous blowouts. Several cycles of erosion (valley cutting and pedimentation) followed by deposition of sediment by wind and water have been recognized. Outstanding examples of these glacial activities are seen on the floor of Jackson Hole and the Bull Lake, Dinwoody and Jakey's Fork terminal moraine on the highway between Lander and Dubois.

During the Recent Epoch erosion and deposition of alluvium continued. Man arrived in North America.

Superimposed drainage

The master drainage pattern of Wyoming does not conform to existing relief. The larger rivers have cut deep canyons through mountain ranges.

The Wind River canyon is an example and there are many others both large and small. If the drainage were to form on the present surface, the rivers would flow between and around the ends of the mountains rather than across them. This interesting feature of the drainage pattern is explained as follows.

When the rivers established their present courses, they flowed on a surface formed on Miocene or Pliocene rocks. These rocks then covered the lower portions of the dissected mountains. Some mountain passes are still buried beneath them. The streams, after cutting through the blanket of Miocene and/or Pliocene sediments, encountered the more resistant rocks of the buried mountains. As the basins were excavated and the less resistant sediments were stripped from the mountain flanks, the rivers maintained their courses by cutting precipitous canyons through the more resistant rocks of the mountains. The rivers are therefore superimposed upon a surface which is now destroyed. The basin floors cannot be lowered by river erosion any faster than the rivers can deepen these canyons.

Acknowledgments

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Minerals and Oil

ROBERT S. HOUSTON[7]

The State of Wyoming ranks tenth in the valuation of mineral production among the states of the Union. This includes production of metallic and nonmetallic minerals as well as petroleum products. The value of mineral production was $504.8 million in 1964, a record high for the state (Meeves and Koch, 1965). Thomas (1965) indicates this is approximately three times the value of agricultural products, and is the primary source of income as well as a major source of tax revenues for the State. In 1964 petroleum ranked first in value constituting 69.5 percent of the total. According to Meeves and Koch (1965) other major mineral commodities ranked, as follows:

Natural gas and related products	8.3%
Uranium and vanadium	5.6%
Iron ore	4.9%
Clay *(bentonite largely)*	2.5%
Coal	1.9%
Sand and gravel, stone	1.9%
Other products chiefly trona *(sodium carbonate)*, gypsum, and phosphate rock	5.4%

PETROLEUM AND NATURAL GAS

Petroleum and natural gas products outweigh other mineral products in economic importance constituting about 78 percent of the total value. A recent survey, (1966) by the Independent Petroleum Association of America shows Wyoming fifth among the states in crude oil production with an average daily production of 378,900 barrels of oil. The survey also indicates that Wyoming is fifth in proven oil reserves with 1.15 billion barrels. Wyoming ranks high in proven reserves of natural gas with over 4 billion cubic feet, placing the state seventh in the nation.

Oil and natural gas are produced from rocks of Paleozoic, Mesozoic and Tertiary age. Production is primarily from structural and stratigraphic traps located along the margins of sedimentary basins (Fig. 5). Most early discoveries of oil and gas were made using the anticlinal concept of exploration in which the geologist searched for anticlines with enough closure to constitute a structural trap (that is, dome-like structures in which oil and gas are trapped in the upper part of the structure). Because of the excellent surface exposures of rocks in Wyoming, most of these early discoveries were made by use of the cheapest of exploration tools: surface geological mapping. After the conspicuous anticlinal structures were drilled, more complex types of structural traps such as fault traps were investigated. Where surface rock exposures were poor or beds of interest covered by recent sediments, more expensive geophysical techniques were employed.[8] During this period of emphasis on the search for structural traps, several important discoveries were made of oil fields that were ultimately classified as stratigraphic traps. These stratigraphic traps

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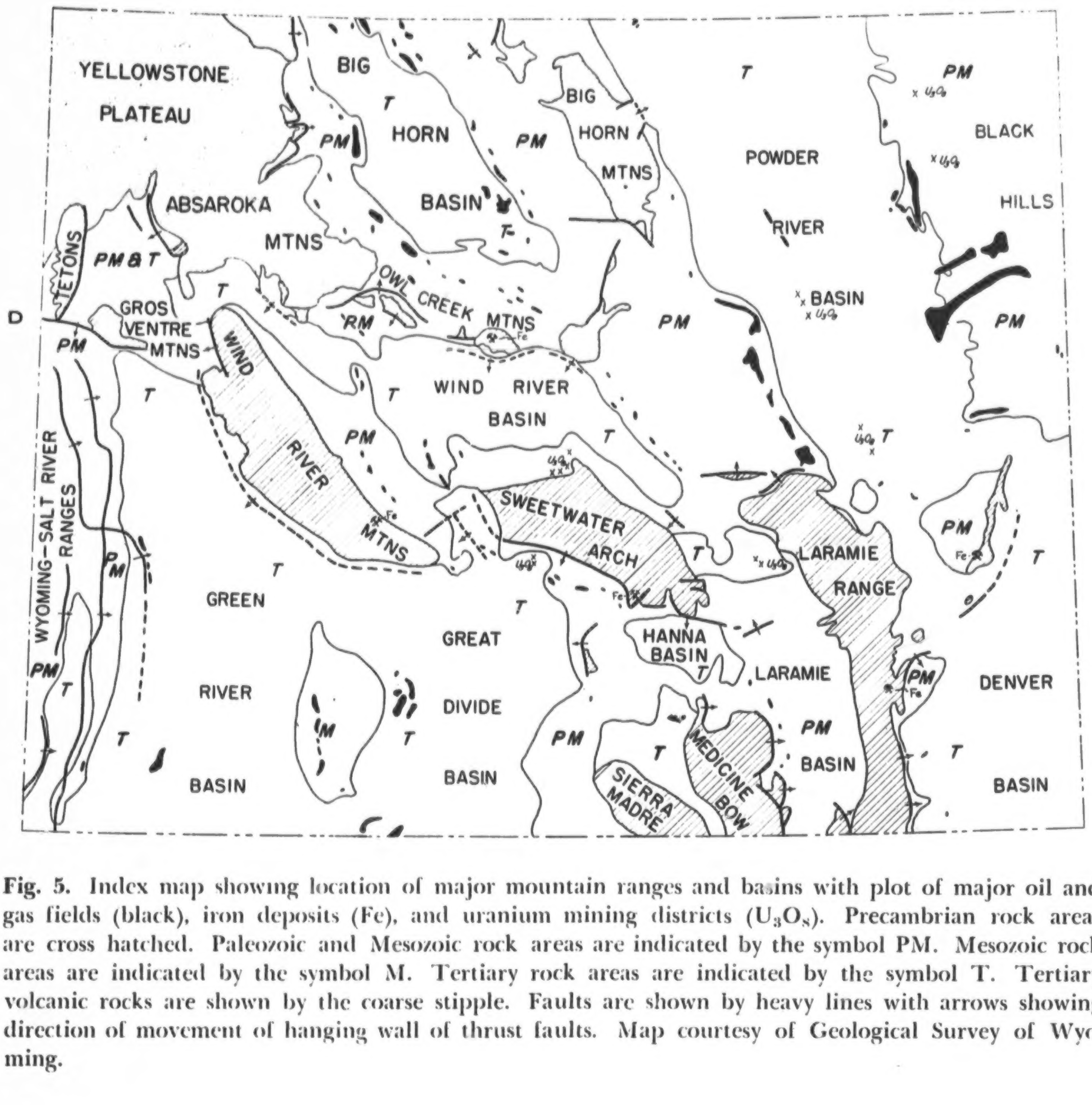
[7] Professor of Economic Geology, University of Wyoming.

[8] Geophysical techniques include seismic methods (essentially the use of artificial earthquakes to study rocks) and gravity methods (comparison of specific gravity of rocks).


YELLOWSTONE
PLATEAU
BIG
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WIND RIVER
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RANGE
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BASIN
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HANNA
BASIN
LARAMIE
PM
BASIN
MEDICINE
BOW
SIERRA
MADRE
DENVER
BASIN
Fe
U_3O_8

Fig. 5. Index map showing location of major mountain ranges and basins with plot of major oil and gas fields (black), iron deposits (Fe), and uranium mining districts (U_3O_8). Precambrian rock areas are cross hatched. Paleozoic and Mesozoic rock areas are indicated by the symbol PM. Mesozoic rock areas are indicated by the symbol M. Tertiary rock areas are indicated by the symbol T. Tertiary volcanic rocks are shown by the coarse stipple. Faults are shown by heavy lines with arrows showing direction of movement of hanging wall of thrust faults. Map courtesy of Geological Survey of Wyoming.

proved to be prolific producers of oil and gas and include the Glenrock field, Converse County, and the Mush Creek-Skull Creek field in Weston County (Fig. 6).

Beginning in the 1950's and especially in the late 50's, three major shifts were made in exploration for petroleum in Wyoming. Geologists recognized that important production of oil and gas came from rocks of Tertiary age (these rocks constitute about ⅓ of the total thickness of sedimentary rocks in Wyoming). Although there had been production as early as 1896 from Tertiary rocks, the oil was thought to have migrated into the Tertiary beds from below and thus be simply displaced Paleozoic and Mesozoic petroleum (Love, McGrew, and Thomas, 1963). It has been demonstrated by geochemical studies that most of the Tertiary oil actually originates in Tertiary source beds and this opened a new phase of exploration in the rocks of Tertiary age.

The second major change in exploration thinking was to place emphasis on the search for the stratigraphic trap. Exploration for stratigraphic traps requires a much more detailed knowledge of geology with emphasis on environmental and stratigraphic studies. The opportunities for finding such traps in Wyoming are enhanced by the excellent surface outcrops that allow the geologists to study the rocks in detail on the surface and project such information into the subsurface.

The third major change in exploration thinking was recognition that oil could be found in the center or deeper parts of basins as well as along

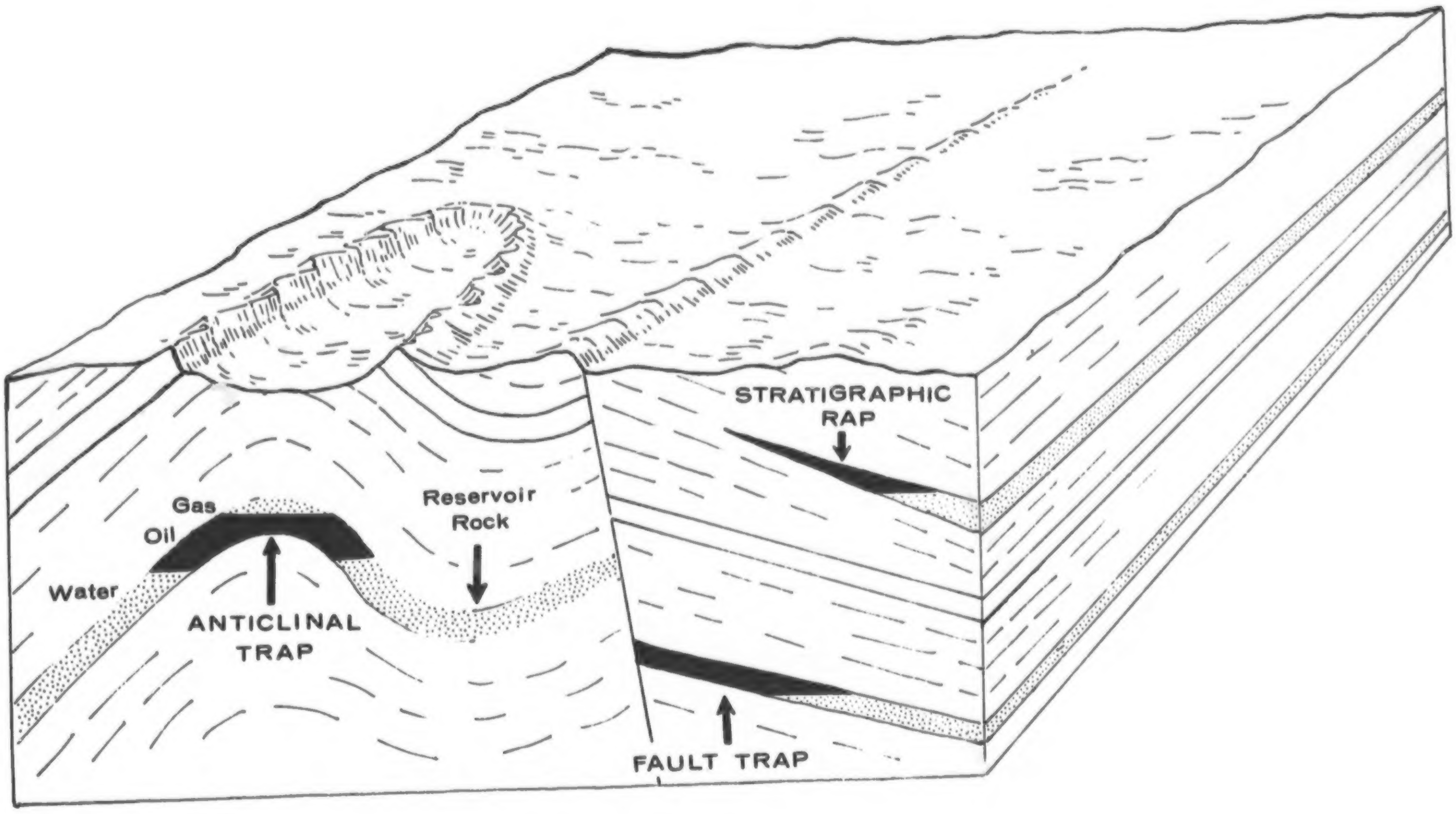

Fig. 6. Block diagram showing various types of geological traps for oil and gas. The oil and gas migrate through permeable sandstone beds (dotted pattern) that are water saturated. The oil and gas collect at the top of these sandstone beds because they are lighter than water. If some rock type that is impermeable such as a shale (dashed pattern) lies above the sandstone or surrounds it, the oil and gas cannot continue to move upward and will be trapped. If the sandstone bed is warped or folded into a dome-like structure the oil and gas will collect in the upper part to form an anticlinal trap. If the sandstone is cut-off by a fault the oil and gas will migrate upward to the fault and form a fault trap. If the sandstone simply pinches out the oil and gas will migrate upward and collect at the shale contact to form one type of stratigraphic trap (Block diagram by S. H. Knight).

the margins. Exploration in the deeper parts of basins had been discouraged because geologists thought the porosity and permeability (the ability to transmit fluids through rocks) of producing horizons would be too low in the center of the basin. This assumption has been shown to be false as illustrated by the discovery of a major oil field by the Shell Oil Company at 15,000 to 16,000 feet in the Powder River Basin.

These new approaches to exploration in Wyoming offer promise of future discoveries that may significantly increase the petroleum and natural gas reserves of the state.

METALLIC AND NONMETALLIC MINERAL DEPOSITS THAT ARE MINED TODAY

Uranium and Vanadium

Wyoming is second among states in production of uranium. The United States Atomic Energy Commission (1966) estimates that Wyoming has 36 percent of domestic uranium reserves. The last major discovery of uranium ore in the United States was made in the Shirley Basin area of Wyoming in the late 50's. Since that time the economy of the federally subsidized uranium industry has been such that little exploration has been undertaken. However, major strides have been made in recent years in commercial use of uranium; power produced by atomic reactors has been found to be competitive with other sources of power much sooner than expected. The result has been renewed interest in exploration for uranium and a concentrated search began in Wyoming in the summer of 1966.

Uranium has been found in rocks of virtually every geologic age in Wyoming from the Precambrian to the Recent, but the major deposits are in the Eocene beds of the Tertiary. The chief deposits are in sedimentary basins that contain arkosic sandstones of Eocene age; the producing horizons are in the Wind River formation and the Wasatch formation. Major production is in the Wind River Basin, Shirley Basin, and Powder River Basin (Fig. 5).

Uranium mining is a product of the mid-twentieth century in Wyoming (Fig. 7). Although

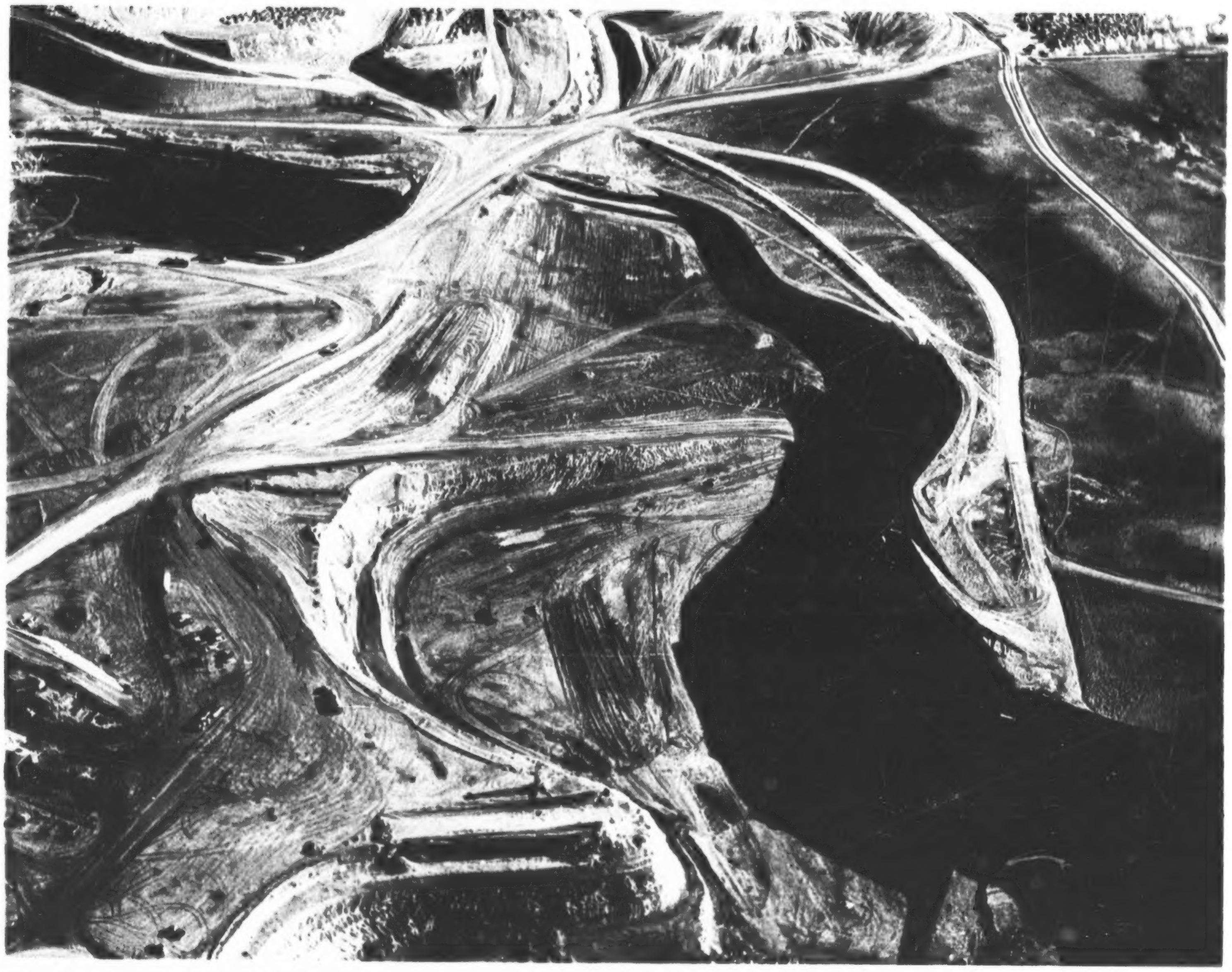

Fig. 7. Open pit mining operation for uranium in the Gas Hill district, Wyoming (Photo by P. T. Jenkins and L. P. House, August, 1959).

minor occurrences of uranium minerals were discovered as early as 1918, it was not until 1952 that the first significant discoveries were made in the Powder River Basin by a party of United States Geological Survey geologists led by J. D. Love. Reports of this find led to intensive exploration by geologists and, more significantly, prospectors from all walks of life. The exploration effort was aided by airborne surveys made by the Atomic Energy Commission; in 1953 major ore deposits were discovered in the Wind River Basin that resulted in the development of the mining and processing industry of today.

The occurrence of uranium in arkosic sandstones of Tertiary age proved to be a completely new and unexpected type of mineral deposit. Detailed studies of the deposits by geologists of various mining companies, the United States Geological Survey, and the Atomic Energy Commission have shown that the uranium occurs primarily in a half-moon or roll-shaped deposit (Fig. 8), and is believed to have been precipitated at a so-called chemical front[9]. The uranium roll is in the arkosic bed which is usually a good aquifer (that is, a bed that is water saturated and allows free fluid movement). The arkosic bed is usually overlain and underlain by shale that helps confine the flow of liquid to the arkose proper. Uranium bearing waters are believed to gain access to the arkosic bed and when the chemical composition of the water changes (perhaps from oxidizing to reducing conditions) the uranium along with vanadium, selenium and other elements is precipitated. The source of the uranium has been debated for years with some geologists believing that the uranium is leached from overlying volcanic beds called tuffs (Love, 1952) and others believing that the uranium is actually leached from the minerals of the arkose. Although the actual source is very important to exploration, Wyoming is in a good position for future discoveries because most Tertiary arkosic beds were overlain by tuffs at some period in their history, and these arkosic beds are in other basins as yet not thoroughly explored including the Green River, Washakie, Great Divide, Hanna and Cooper Basins. Especially in the Gas Hills district the uranium is present in blanket-like deposits in arkosic sandstone in addition to the half-moon or roll-shape.

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[9] Especially in the Gas Hills district the uranium is present in blanket-like deposits in arkosic sandstone in addition to the half-moon or roll-shape.

Iron Ore

Preliminary estimates of the U. S. Bureau of Mines (Meeves and Koch, 1966) show Wyoming production of iron ore in thousand long tons at 2,135, an increase of about 4 percent in quantity and 11 percent in value over 1964. The production is entirely from deposits in rocks of Precambrian age, and the deposits are similar geologically to those of the Lake Superior region of the northcentral United States. Wyoming has been a producer of iron ore since the 1890's where high grade hematite ore has been mined by the Colorado Fuel and Iron Company from its Sunrise Mine in Platte County. This is a secondarily enriched deposit of hematite derived from alteration of iron ore of sedimentary origin. Another iron deposit of sedimentary origin has been developed by United States Steel in the Atlantic City area of Fremont County. This is a large deposit of magnetite-type ore that is not enriched and thus is lower grade than that at Sunrise. It is similar to the taconite ore of the Lake Superior District. Although these are the only deposits mined in Wyoming today, sedimentary-type iron deposits are known in three other areas, the Seminoe Mountains (Lovering, 1929), northern Wind River Mountains (Worl, 1965), and the Owl Creek Mountains (Gliozzi, J. and Millgate, M., personal communication, 1966).

Wyoming also has large tonnages of iron ore in other types of deposits. In the Laramie Range major deposits of iron and titanium minerals are in anorthosite, a Precambrian igneous rock, (Newhouse and Hagner, 1960), but the titanium and iron minerals are so intimately intergrown that they are expensive to separate. Iron and titanium minerals are also in black sandstone in rocks of Cretaceous age in Wyoming (Houston and Murphy, 1962), but here again there is a separation problem.

Large reserves in both iron producing areas and the likelihood of development of other known iron deposits indicates increased production in future years.

Trona

Trona is hydrated sodium carbonate and sodium bicarbonate ($Na_2CO_3.HNaCO_3.2H_2O$). It is a natural source of soda ash (sodium carbonate) that has extensive use in the chemical industry and is required in the manufacture of such items as ceramics, glass, soap, detergents, paper, and textiles. Wyoming has the largest deposit of trona in the United States and probably in the world, and is also the largest U. S. producer of soda ash. According to Culbertson (1966) there are 24 beds more than three feet thick that contain about 67 billion tons of trona. The trona was deposited in an enormous lake that covered much of southwestern Wyoming during Eocene time. During a dry climatic cycle the lake was greatly reduced in size by evaporation and beds of trona were deposited in most of the area between latitude 41° and 42° N. and longitude 109°-110° W., the western half of Sweetwater County. The beds are 40 feet or more in thickness in some areas.

The beds of trona do not crop out on the surface and were discovered by drilling for oil in an area west of Green River in 1938. The first production was by the FMC Corporation and Westvaco Chemical Corporation beginning in 1946. Because of the extraordinarily large reserves and increased demand for trona, other chemical companies became interested in the Wyoming deposit in the late 50's. A second mine was subsequently opened by Stauffer Chemical Company in 1961, and a third mine by Allied Chemical Company in 1966.

Today the FMC plant west of Green River is the world's largest producer of soda ash, and if current plans are implemented the Stauffer plant will soon become the second. Since reserves are well documented it will simply be a matter of time until other plants are opened in this area indicating how an important product may be discovered, by drilling for another.

Coal

The coal present before the beginning of mining in Wyoming has been estimated conservatively as over 121 billion short tons (Berryhill, *et al.*, 1950). This places Wyoming fourth among states in original coal reserves. In 1945 coal production in Wyoming was close to 10 million short tons (Averitt, 1965) as a result of increasing production to meet war time needs. Production declined following the war and was 6 million short tons in the early 50's approximating pre-war tonnage. This normal decline was followed by a sharp decrease resulting largely from the rapid change from coal to diesel locomotives on western railroads, and in 1957 coal production was less than 2 million short tons (Averitt, 1965).

Primarily, because of increasing use of coal in electric utility plants production has increased gradually from its low in the late 50's to 3.2 million short tons in 1965 (Meeves and Koch, 1966). Paul Averitt (1965) of the United States Geological Survey estimates that increasing coal consumption by utilities may result in an increase to 4.5 million short tons by 1970.

The coal reserves of Wyoming are also in the sedimentary basins. Production is from coal beds of Cretaceous and Tertiary age with major reserves in the Powder River Basin, Green River Region, Hams Fork Region, and Hanna Field. The United States Geological Survey states that 41 percent of the state is underlain by known or probable coal-bearing beds. They also state that 53 percent of this area is not included in their estimate of 121 billion short tons because so little information is available. This indicates that coal reserves will be substantially increased in the future. The future of the coal industry will therefore not be dependent on reserves but on the demand for coal in the domestic and world market.

Unquestionably the demand for coal in the utility industry for the production of electricity will increase, but the future of coal depends to a large extent on research in such areas as improved production of coke, char, and chemicals and the manufacture of synthetic oil from coal.

Bentonite

Bentonite is a name given to an aggregate of clay minerals that develop by alteration of beds of volcanic ash. The chief clay mineral in bentonite is montmorillonite which is actually a group of clay minerals including nontronite, beidelite, and montmorillonite proper. These minerals are hydrated aluminum silicates having varying amounts of Na, Ca, Fe, Mg, and Al in the mineral lattice. The mineral of the group that is now called montmorillonite has the chemical formula $(Na)_{0.7}(Al_{3.3}Mg_{0.7})Si_8O_{20}(OH)_4.nH_2O$. Montmorillonite along with other minerals of this group is a "swelling clay". That is, the mineral will swell to several times its normal size by taking up water or organic liquids between the structural layers. Bentonite is used in the oil industry as an ingredient in drilling mud, and in the processing of taconite-type iron ores. It is also used in the manufacturing of paper, rubber, ceramics, paints, for bonding molding sand, in water purification, and fire-fighting slurries.

Bentonite beds in Wyoming are present in most of the sedimentary basins of the state with principal production from the Powder River and Bighorn Basins. The bentonite was formed by alteration of volcanic ash beds that were deposited in seas that covered the state during Late Cretaceous time. The major deposits are in the Frontier formation and the most important single deposit was in the Clay Spur bentonite bed found near the base of the Frontier formation.

Wyoming bentonite is of excellent quality and is used as a standard of excellence in the industry. Production has increased in recent years reaching 1.3 million tons in 1965, nearly 70 percent of the domestic supply (Meeves and Koch, 1966).

Gypsum

Gypsum is hydrated calcium sulphate ($CaSO_4.2H_2O$) a mineral deposited by evaporation of natural waters. It is used in the manufacture of plaster and plaster products such as a wall board, and in the cement industry. Deposits of gypsum in Wyoming are in beds of Permian, Triassic, and Jurassic age. They were deposited in shallow seas where there was a high rate of evaporation. The reserves of gypsum in Wyoming have been estimated by the United States Geological Survey (Senate Doc. 76, 1960) as nearly a billion tons averaging more than 90 percent gypsum in beds 5 feet or more thick. Since gypsum must be mined near the surface by low cost methods the reserves are for beds that are no more than 30 feet below the surface.

In 1956 Wyoming produced only 11,380 tons of gypsum and the state was thought to be too distant from markets for successful competition, but today (1966) new plants have been constructed in the Bighorn Basin for the manufacture of gypsum wallboard and production has more than doubled in the last three years.

Phosphate Rock

Beds of the Phosphoria formation of Permian age located in western Wyoming contain large reserves of phosphate rock. Prosphate rock is a type of sedimentary rock that contains as much as 20 to 36 percent P_2O_5. The phosphate is present in the rock as some form of the mineral apatite ($Ca_5(F, Cl, OH)(PO_4)_3$). Commonly these phosphate-rich rocks also contain other elements in minor amounts that may be produced as a byproduct of mining for phosphate. The other elements include molybdenum, uranium, fluorine, vanadium, lead, nickel, cerium, yttrium, and certain other rare earth elements. The phosphate rock mined today, however, is used chiefly for the manufacture of superphosphate which is phosphate rock treated to make the phosphate water soluble and thus useful as fertilizer.

Phosphate rock is mined by the San Francisco Chemical Company at a locality 25 miles west of Kemmerer, Wyoming. In 1964 the tonnage of ore processed at this locality was 180,154 tons. Production of phosphate rock may increase twofold in the near future because the Susquehanna Corporation plans to construct a plant capable of processing 150,000 to 250,000 tons of finished product per year at a locality in the Lander-Riverton area.

Other Minerals

In 1965 the United States Bureau of Mines reports (Meeves and Koch, 1966) that there was production of beryllium, raw materials for the manufacture of cement (chiefly shale and limestone), limestone, pumice, silver, copper, gem stones, gold, and sulphur. There was also production of sand and gravel valued at $7.1 million and stone valued at $3.65 million.

With the exception of sand and gravel, stone, and cement the value of these minerals was not large, but as will be noted below certain of these "minor" minerals may be mined in much greater amounts in the future.

MINERAL DEPOSITS OF POTENTIAL VALUE

There are a number of known mineral deposits in Wyoming that may have great value in future years. These include oil shale, copper-molybdenum deposits, titanium, potash, gem stones, and thorium and rare earth elements.

The value of oil shale depends on many factors such as mining methods, depth of overburden, number of gallons of oil that can be recovered per ton of shale. At present, oil produced by mining and processing shale may not be competitive with liquid petroleum, but it may be competitive in the near future and there are individuals that believe shale oil could compete at today's prices (Nielsen, 1966). The future of the oil shale industry also depends on a large extent on decisions that are made by the Federal government on leasing shale land since most deposits are on federally owned land.

The oil shale deposits of Wyoming are in the Green River Basin of southwestern Wyoming in the same lake beds of Eocene age that contain the deposits of trona. The reserves have been estimated (Culbertson, 1964) as 370 billion barrels of oil in place from shale averaging 10 gallons of oil per ton and having a thickness of 15 feet or more. This is a striking figure when compared with proven liquid petroleum reserves of 1.15 billion barrels in Wyoming.

Primarily as a result of mapping by W. H. Wilson of the Geological Survey of Wyoming (Wilson, 1964) it has been recognized that certain igneous bodies of Tertiary age in the Absaroka Mountains of Wyoming contain large tonnages of low-grade copper-molybdenum (Fig. 8). These igneous bodies contain disseminated sulphide minerals in altered zones that to some degree resemble the porphry copper deposits of the Southwestern United States. Two of these deposits are being carefully explored by mining companies, and may be producers of copper-molybdenum in the foreseeable future.

Titanium minerals occur in two types of deposits in Wyoming, in veins and disseminated deposits in anorthosite of the Laramie Range (Newhouse and Hagner, 1950), and in ancient beach placers or black sandstone in sedimentary rocks throughout the basins of the state (Houston and Murphy, 1963). Both types of deposits contain large tonnages of titanium bearing minerals, but in both cases the titanium-bearing minerals are so intermixed with iron-bearing minerals that it is expensive to separate them. When ores that are cheaper to process are exhausted or when low-cost techniques of separation of these iron-bearing and titanium-bearing minerals are devised these deposits will be exploited.

Wyoming has the largest reserves of potash-rich igneous rocks in the United States. These deposits are in the Leucite Hills north of Rock Springs. They contain over 1.9 billion tons of potash-rich igneous rocks that average 10 percent K_2O, and 10 percent alumina (Al_2O_3) (Schultz and Cross, 1912). The potash is much more expensive to extract from igneous rocks than from saline deposits of the type that produce most potash for today's market. For this reason, the Wyoming deposits will not be mined unless a new and cheaper process of extraction is developed.

Both precious and semi-precious gem stones have been mined in Wyoming including jade, agate, opal, and petrified wood. Jade is, by far, the most important of these, and probably accounts for the greater part of the $120,000 sales of gem stones estimated by the Bureau of Mines in 1965. The actual value of gem stones in the state's economy probably far exceeds the estimated value of production. Much of the gem stone is collected by amateurs or "rock hounds" who come to Wyoming specifically to search for gem stones or simply unusual minerals and rocks. These collectors must be significant contributors to the tourist trade of the state as are those who come to fish and hunt.

THE MINERAL INDUSTRY AND THE STATE'S ECONOMY

Few people campaign for public office in Wyoming who do not emphasize the state's vast mineral resources and the need for increased de-

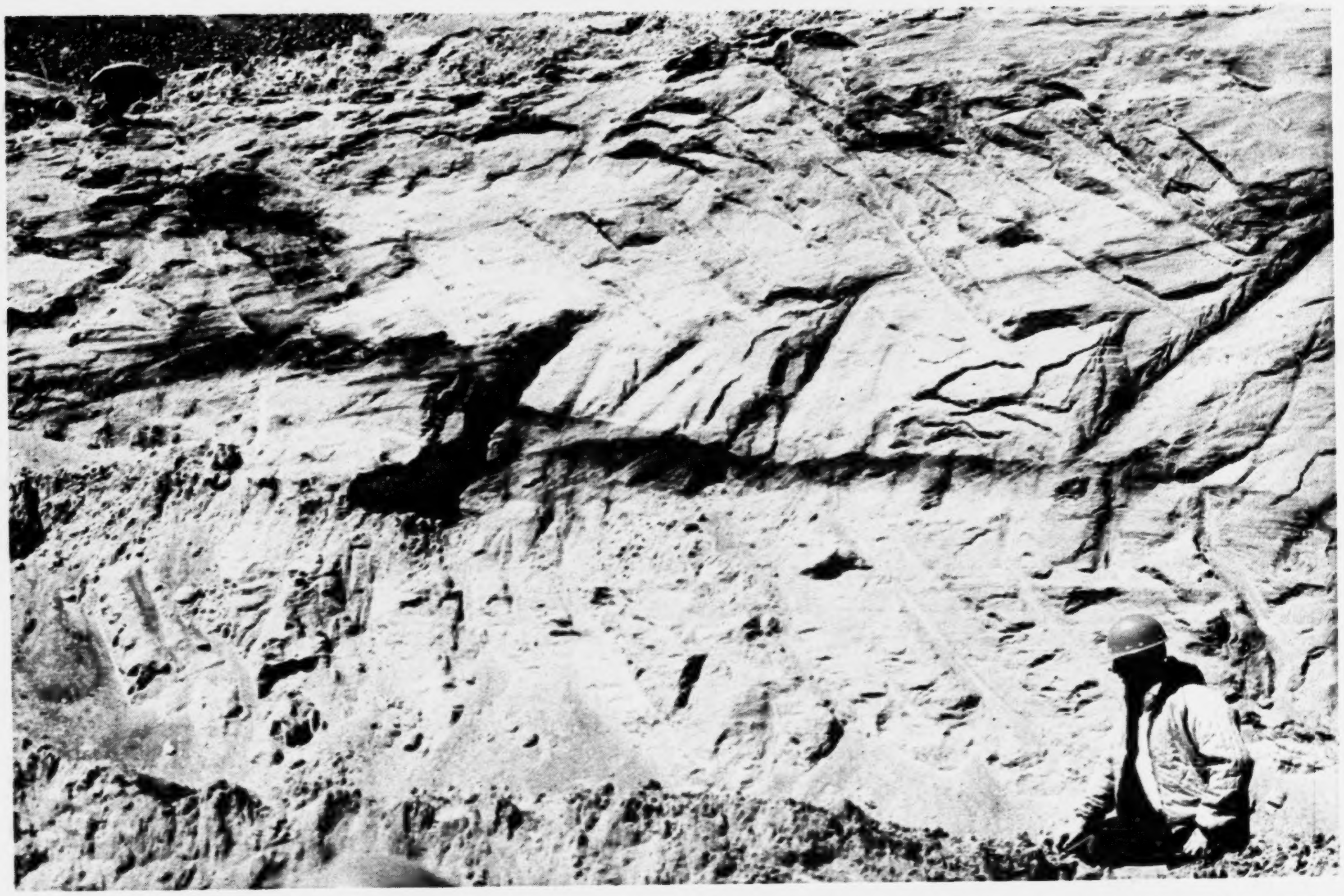

Fig. 8. Lower one-half of a uranium roll in wall of open-cut mine, Shirley Basin, Wyoming. The uranium is concentrated in the dark-colored zone. The upper-half of the roll has been stripped off, but was a mirror image of the lower part. The black, uranium-rich zone was shaped like a U lying on its side.

velopment of mineral deposits to improve the economy. One has simply to witness the tremendous improvement in general economy of southwestern Wyoming as the trona deposits have been developed in recent years or the greatly improved employment picture of the Lander-Riverton area as the new iron deposits were opened at Atlantic City to realize how important a mineral industry can be to a given region in the state.

The development of mineral deposits is especially important in a state such as Wyoming where job opportunities are limited because of relatively few industries and declining employment in farms and ranches. Mineral deposits may create jobs of many types including jobs in the extracting phase, processing and refining phase, and most important in the development of industry based on the availability of low cost raw materials. In general, the people of Wyoming have benefited most from the first two phases in the development of the state's mineral deposits. Many jobs have come from employment in the extracting phase of the industry and this type of employment will continue so long as there is a mineral industry in the state. In general, more and better paid jobs are to be had if the mineral is processed to some type of finished or semi-finished product. Examples are the refining of raw petroleum to gasoline and other products, the manufacture of soda ash from trona, and wallboard from gypsum. If the people of Wyoming are to gain maximum benefit from the state's natural resources every effort must be made to insure that mineral resources are processed as far as is economically feasible before shipment out of the state.

Wyoming is to some degree in the position of a small mineral-wealthy country that gains most of its revenues from the sale of raw material, but does not benefit nearly as much as an industrialized country that uses these same raw materials to manufacture finished products. Today, most corporations depend more on a regional market than a local market. Wyoming, being centrally located with respect to large markets on the Pacific Coast and in the Midwest, may be an attraction to more industry in the years to come. At least, we hope, that as new mineral deposits are found and developed they will be fully processed in Wyoming.

Acknowledgments

Helpful comments, suggestions, and contributions were made on the manuscript by W. H. Wilson of the Geological Survey of Wyoming, J. D. Love of the United States Geologic Survey, and S. H. Knight, professor emeritus, University of Wyoming.

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Wyoming Soils

JOHN A. BARTRUFF[10]

The soil as well as other natural resources must be understood in order to be developed, used and managed for best present and future interests of mankind. For people, in general, to appreciate and help both urban and rural areas in conservation efforts it is necessary to know the typical characteristics and capabilities of the soil.

Of the total area of approximately 62.6 million acres of land in Wyoming, about 4 percent is used for crops, 80.6 percent for grazing (includes forested range), 10.4 percent for forests and watershed, and about 5 percent for roads, railroads, urban areas and miscellaneous uses (Table 1).

There are many different kinds of soil in Wyoming. This is due to the wide variety of parent materials in the different exposed geologic formations and to the varying proportionate actions of the soil forming factors in different parts of the state.

The interplay of climate, topography, physiography, vegetation and time on the exposed rock and soil has given us our varied landscape. The variations from the dry cropland areas through the midgrass, shortgrass, semi-desert land to the forested lands provides an interesting insight into the development of our soils. In Wyoming the effect of the soil-forming factors are extremely varied. For example, altitude, which affects precipitation and temperature, in Wyoming ranges from a low of less than 3500 feet where the Little Missouri River leaves Wyoming to as high as 13,785 feet on top of Mt. Gannet, the highest point in Wyoming.

Table 1. Land use in Wyoming*

LAND USE	THOUSANDS OF ACRES
Non-Federally owned	
Cropland	
Irrigated	1,469
Non-irrigated	1,092
Pasture and range	28,638
Forest and woodland	1,586
Other land	153
Total	32,938
Federal and miscellaneous land	
Federal land	29,329
Urban and builtup areas	267
Water areas†	95
Total	29,691
Approximate total land area	62,629

*Compiled from: U. S. Department of Agriculture. 1963. Wyoming soil and water conservation needs inventory. Wyoming Conservation Needs Committee, Soil Conservation Service. Casper and Wyoming Agricultural Experiment Station. 1965. Wyoming agriculture. Univ. Wyo. Agr. Exp. Stat. Cir. 211.

†Water areas of less than 40 acres in size and streams less than ½ mile in width. (Water areas over 40 acres in size or streams more than ½ mile wide are not included in the total land area.)

The annual precipitation ranges from 5 inches in the Red Desert and parts of the Bighorn Basin, to 45 inches in the mountains. Frost-free periods vary from a few days to 120 days in the lower elevations.

In addition to the kind of parent material, climate, and time, topography, and plant and animal life are also basic factors in determining the characteristics of the soil. The proportionate effect of these varies from one part of the state to another, from one farm to another, and in fact from one field to another. In most cases the character and productivity of a given soil depends to a greater degree on factors other than parent material. For example, soil formed from sandstone in the High Desert Soils area in Sweetwater

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[10] Former Wyoming State Soil Conservationist, Soil Conservation Service. U. S. Department of Agriculture.

County are quite different from the soil formed from sandstone in the Central Plains Soils area in Goshen County.

Plants need water, air, nutrients, and a place to establish their root systems. The ability of a soil to supply these needs, depends on the size, shape, arrangement, mineral composition of its particles, and the form and amount of pore space. There are four major components of soils: mineral particles, organic material, water and air. The proportions of these vary greatly from place to place and with depth.

Mineral or inorganic soil particles occupy about one-half of the total volume of most soils. They are derived from the mechanical fragmentation and chemical decomposition of the bedrock. The particles vary not only in size from microscopic to readily seen gravel and stone, but also in chemical composition depending on the kind of original rock or parent material.

The organic material in the soil comes from decomposed vegetable and animal matter such as grass, shrubs, worms, insects, etc. These particles, like minerals, vary in chemical and physical characteristics.

When determining the capabilities, hazards, and limitations of soils for various uses, it is necessary to know the proportions of particles in the various size groups—gravel-sand, silt-clay. The percentage of sand, silt and clay determines the texture of the soil. The texture of soil refers to the proportion of different sized particle groups in terms and percentage. The large particles have a low surface area per cubic foot of soil. Soils containing large amounts of gravel or sand have little or no plasticity and do not retain large amounts of water and nutrients. They can easily transmit water and air, because of the large pore space between the particles.

Most of the important chemical activities take place at the surface of the particles. The smaller particles with their larger surface area per unit of mass provide most of the physical and physical-chemical activity favorable to good soil development.

Silt particles have greater chemical activity than sand and are more plastic and have better cohesion. The physical-chemical activity in the sands and silts is not sufficient to give the most desirable physical behavior to soils with little or no clay.

The clays provide the major part of the psysical-chemical activity and control the most important properties of soil.

Soil structure refers to the aggregation of primary soil particles in groups or clusters. On soils that contain substantial amounts of silt and clay, many of the particles are grouped into secondary structural units, called aggregates. The size, shape and arrangement of the soil aggregates largely determines the size and distribution of pore space. These factors, in turn are important in providing water holding capacity, good drainage, aeration, good tilth and available plant food.

Soil aggregates are not permanent structural units, particularly in the surface of cultivated soil. Many of the soil management problems such as compaction, crusting and cracking revolve around the amount and kind of clays and the structure of the soil.

Every soil has a profile — a succession of layers or horizons in a vertical section down into loose weathered rock (Fig. 9). They may vary in thickness from a barely discernable line to several feet. The horizons differ and may be recognized by a difference in color, texture, structure, consistency, porosity and reaction.

Most soils have three horizons that are identified as A B and C. For scientific study and management purposes these major horizons may be further subdivided, as A_1 A_2 A_3 B_1 B_2 etc. Young soils and those formed under conditions unfavorable for soil development like those in the Low Desert Soils area in the Bighorn Basin may show little or no horizon development. The more mature soils and those formed under favorable conditions like those in the Central Plains Soils area in Goshen, Laramie, and Platte Counties have well developed profiles with distinct horizons. *(U. S. Department of Agriculture, 1957)*

Organic matter is usually added to the surface layer in greater quantities than to the deeper ones. Clay and some oxides may be lost from the surface and accumulate in the deeper ones. Losses due to leaching and eluviation increases with the amount of water passing through the soil and varies in different parts of the profile. Generally, leaching and eluviation are greatest in the surface soil. Alterations are due to changes in composition of both mineral and organic matter, and the action of living organisms—plants, animals, bacteria, and fungi.

These changes are slow but continuous and take place at varying rates depending on the proportionate effect, at a given location, of the various soil forming factors—climate-relief, living organisms, parent material and time.

Soils in Wyoming are quite complex and their reactions to different uses and practices are varied, but if their characteristics are known and understood then the reactions are predictable. The

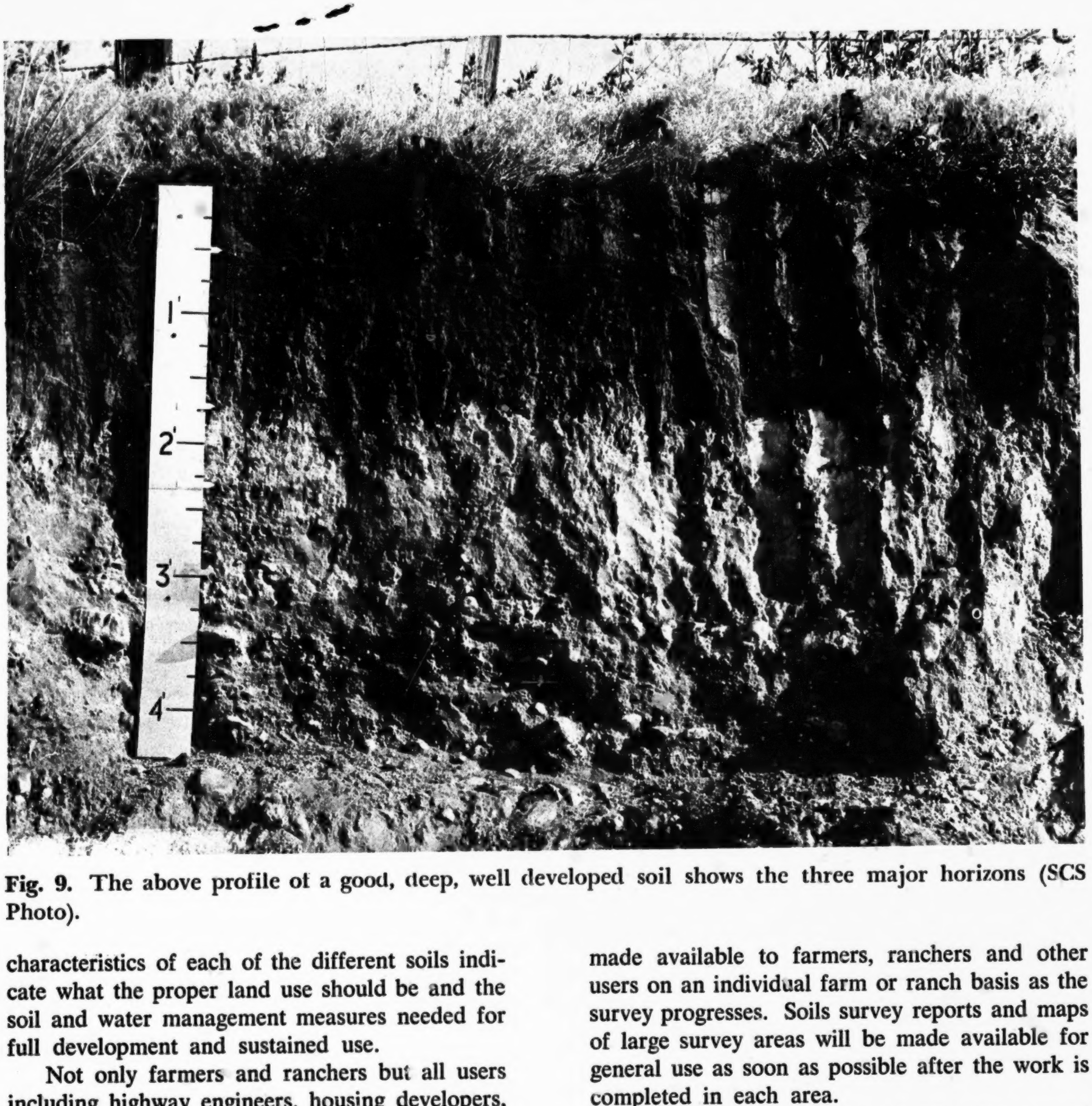

Fig. 9. The above profile of a good, deep, well developed soil shows the three major horizons (SCS Photo).

characteristics of each of the different soils indicate what the proper land use should be and the soil and water management measures needed for full development and sustained use.

Not only farmers and ranchers but all users including highway engineers, housing developers, city planners, and recreationists need to know the characteristics of different kinds of soil.

In order to supply this information the U. S. Soil Conservation Service has been assigned the responsibility of making soil surveys and publishing soil survey reports covering all non-federally owned lands in the State. The mapping and classification of the soils is being carried out in accord with an internationally developed system. The Soil Classification system is quite similar to that used in the classification of plants and animals. Soil scientists use the categories—orders, sub-orders, groups, families, series, and types. However, for practical use, the series, types, and phases of types are the important categories.

As of July, 1966, soil surveys and mapping has been completed on 8.5 million acres in Wyoming. Soils maps and interpretations are being made available to farmers, ranchers and other users on an individual farm or ranch basis as the survey progresses. Soils survey reports and maps of large survey areas will be made available for general use as soon as possible after the work is completed in each area.

Judging from the number of soil series mapped and described to date, Wyoming will have from 700 to 800 soil series and many more soils types. For general planning purposes these are being grouped in large Land Resource Areas.

A soil survey indicates the origin and describes the profile including different horizons, color, texture, structure, consistence, parent material, depth, degree of erosion, soil reaction, soluble salts, inhibiting factors and associated land features. This information can be interpreted into soil capabilities, limitations and hazards, for any proposed use. Interpretations can include information about soil problems such as: (1) the best agricultural use—cropland, grassland, woodland, wildlife land, recreation land, etc; (2) the location and effect of the water table; (3) the salt content and its effect on crops; (4) susceptibility to wind and water erosion; (5) suitability for nonfarm uses such as housing developments, recreational sites, highways and airports.

In Fig. 10 the boundary lines of the six delineated areas were not determined by detailed soil surveys, but their general location was determined by some surveys and by field observations.

The kinds of soil within each of the general areas are many and varied, but possess some similar general characteristics due to origin and climate. Soil temperature is one of the major factors used in delineating the Low Desert and the High Desert areas. The names given the six general areas and the major kinds of soil within each area are descriptive terms and not the names of recognized soil series, families or groups.

Area 1—MOUNTAIN MEADOW SOILS

This general area includes three major kinds of soil: (1) Alpine Meadow Soils; (2) Forest and Mountain Parks and Meadow Soils; and (3) Foothill and Brushland Soils.

The Alpine Meadow Soils

The alpine meadow soils are very cold soils with a mean annual soil temperature of less than 45°F and a mean summer temperature of less than 50 degrees. All soil temperatures are recorded at a depth of 20 inches. These soils have a thin, very dark colored turf that is acid or slightly acid in reaction. They are usually rocky and sandy because soil formation is primarily due to physical disintergration with very limited chemical decomposition. Microbiologic activity is limited primarily to fungus. Horizons are difficult to identify. These soils support no forests. The vegetation is primarily dwarf plants including grasses, clovers, forbs and willows.

The major uses of Alpine Meadow Soils are for (1) watershed; (2) summer sheep range land; and (3) recreation.

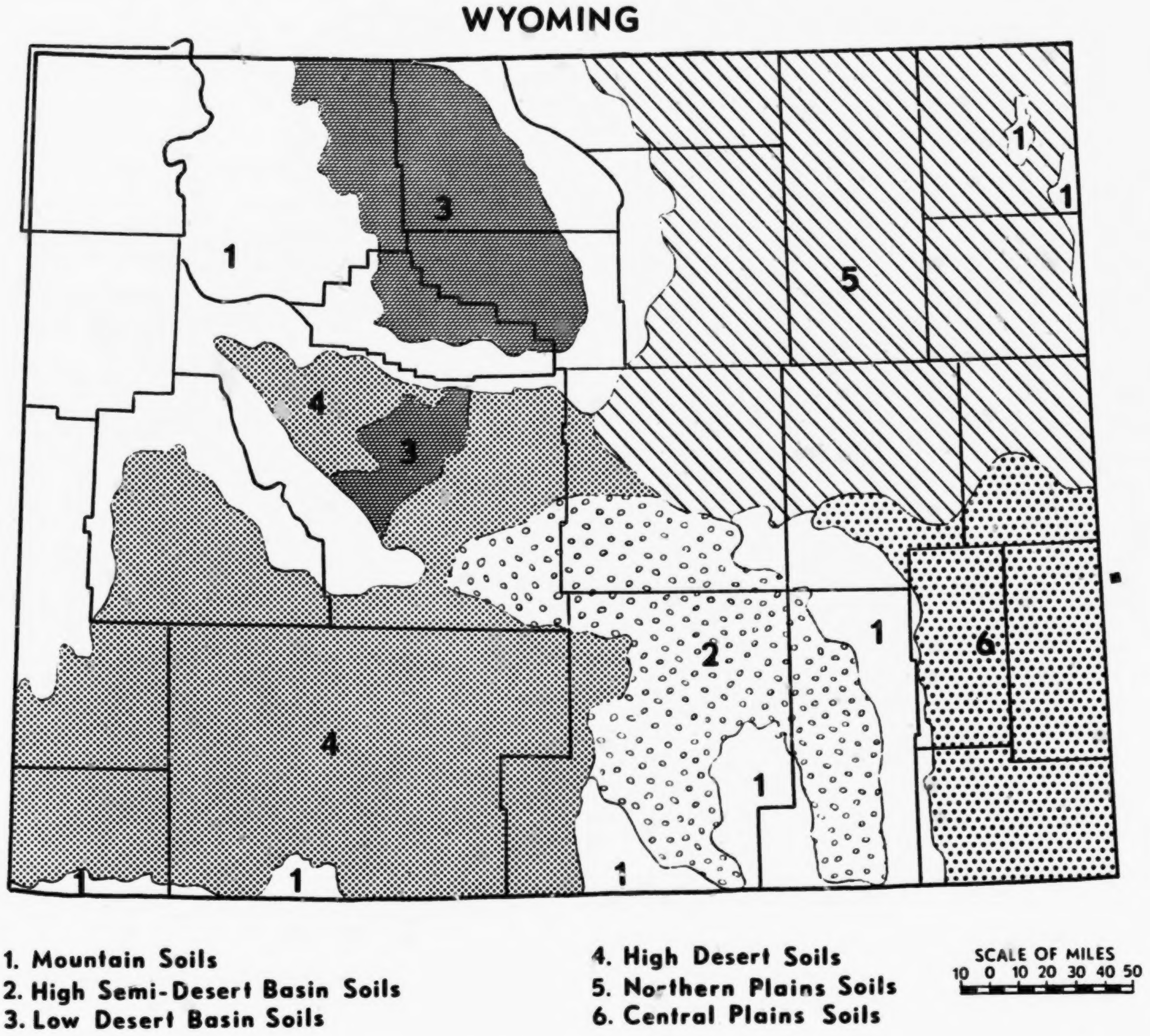
WYOMING
1
3
5
1
1
4
3
6
2
1
4
1
1
1
1
1. Mountain Soils
2. High Semi-Desert Basin Soils
3. Low Desert Basin Soils
4. High Desert Soils
5. Northern Plains Soils
6. Central Plains Soils
SCALE OF MILES
10 0 10 20 30 40 50

Fig. 10. Wyoming soil types and their location.

Forest and Mountain Parks and Meadow Soils

These areas are characterized by a spatter pattern of forest and open parks. The principal vegetation on the forest component is conifers. Mountain grasses and sagebrush on the Park Soils, and water living grasses on the Meadow areas. Forest Soils have a needle mulch surface. They usually have a light colored, mildly acid topsoil and a yellowish yet vincolored subsoil. They are cold and moist most of the time. Park Soils are distinguished by a very thin semi-turf and a dark color that extends to a considerable depth. They are neutral in reaction and often contain considerable rock and stones. They get dry in late summer and early fall. Meadow Soils occupy wet areas and have a peaty surface made up primarily of grass roots. Free water occurs at or near the surface. The subsoil is gray in color.

Forest Soil areas are used largely for timber products, watershed, wildlife, and recreation.

Mountain Park Soils are used for summer range wildlife and recreation. Meadow Soils provide summer range land and water storage with slow release, and wildlife habitat.

Foothill Brushland Soils

These soils are formed in a variety of colors due to various coloration of parent material, but they all have a dark colored surface soil. They are very shallow on the south facing slopes. Textures range from sands to clays depending on the kinds of bedrock. These areas are made up of tilted, interbedded sandstones, shales and limestones. The organic content is relatively high in the surface soil and the soil reaction is neutral to moderately alkaline. These areas are characterized by their unique ridge to trough topography. Their use is primarily for range lands, wildlife habitat and recreation.

Area 2—HIGH SEMI-DESERT SOILS

High Semi-Desert Soils have light colored topsoils with a relatively low organic matter content. These soils contain lime carbonates, some with lime layers, some limey throughout. Those found on the Sweetwater Plateau and in the Saratoga Basins contain higher quantities of lime than in the Laramie and Shirley Basin. These soils are dominantly sandy on the Sweetwater Plateau and Saratoga Basin and loamy and clayey in the Laramie Basin. The soils in the Laramie Basin were developed from bedrocks of an older age than those on the Sweetwater Plateau and in the Saratoga Basin. These soils receive most of their moisture in late spring and early summer. Very little moisture is obtained from snow as it generally evaporates. These areas get dry in late June and remain that way for the balance of the year, however, the total precipitation is higher than in the Low Desert areas. These are predominantly grasslands with local areas of desert shrubs. Wind action is severe.

Major land uses are livestock rangeland, recreation, wildlife habitat, and meadow haylands. There is practically no cash cropping because of climatic limitations.

Area 3—LOW DESERT BASINS

There are three major soil groups in this area: (1) Badland Soils; (2) Shallow Upland Soils; and (3) Alluvial and Mountain Outwash Soils. These areas have a mean annual soil temperature more than 47°F and a mean summer soil temperature more than 60°F. The low precipitation (4 to 9 inches) makes these areas unsuitable for dryland farming. Other uses are winter rangelands, wildlife habitat, and recreation.

Badland Soils

These are nearly baren rough lands with very thin or no topsoil with many gullies and exposures of shale bedrocks. The Badlands have a limited use for sheep winter rangeland, wildlife, and recreation.

Shallow Upland Soils

These soils are light colored and shallow—less than 20 inches to bedrock. They are mostly clays and loams and somewhat salty. The organic matter content is low and there is practically no horizon development. The sparce vegetation is mostly desert shrubs and a very little grass. The Shallow Upland Soils have the same limited use possibilities as the Badlands.

Alluvial and Mountain Outwash Soils

These deep valley fills, washed in from mountain soils, are light colored with white horizons of lime carbonates. They are underlain by gravel and often have gravel throughout the profile. The soil is alkaline and the texture varies widely ranging from sands to clays. The sparce vegetation is mostly grass and sagebrush. The topography is flat to gently sloping. Alluvial soils are suitable for irrigated cropland where water is available.

Area 4—HIGH DESERT BASIN SOILS

The soils in this area are the same as in the Low Desert Basin Soils areas, i.e.: (1) Badlands; (2) Shallow Upland Soils; and (3) Alluvial Sands and Mountain Outwash Soils. They are differentiated from the Low Desert Basin Soils because of their lower soil temperatures. High Desert Basin Soils have a mean annual soil temperature of less than 47°F and a mean summer soil temperature of less than 60°F. The characteristics of the soils in the High and Low Desert Basin areas are similar. The land use is practically the same; however, the annual precipitation is a little higher in the High Desert Basin (8"-10").

Area 5—NORTHERN PLAINS SOILS

There are two major groups of soils in this area: (1) Dark Colored Soils; and (2) Light Colored Soils.

Dark Colored Soils

These sandy textured soils have a dark topsoil. The maturely developed soils have distinctive horizons in the form of color, texture and structural features. The content of organic matter is high. Soil moisture content is erratic, making dryland farming somewhat hazardous although there are some reasonably successful dry farming operations around Sheridan and the Black Hills.

Light Colored Soils

Both the topsoil and sub-soil are light in color. Soil textures range from loams to clays with very little sand. The mature soils have strong structural development and the subsoil has very prominent horizons. They have a reasonable high organic content despite their light color. These soils support a good cover of both mid-grasses and short grasses. Soil moisture supply is erratic, making dry farming hazardous. A considerable amount of cropland has been abandoned and reseeded to grass in this area because of soil moisture limitations. There is some dry farming in the Gillette area, but yields are limited, erratic and uncertain. This is, however, a rather dependable livestock range (Fig. 11).

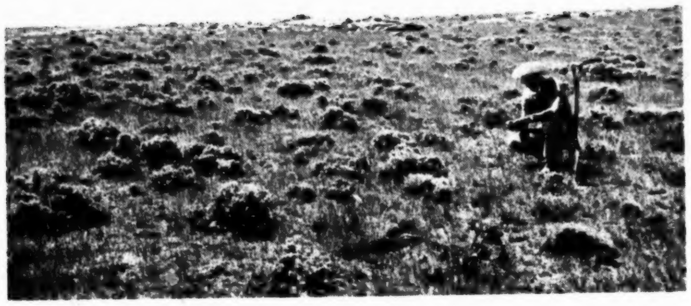

Fig. 11. A shallow soil unable to store much moisture also supports a cover of native grasses and shrubs but of a different kind and amount (SCS photo).

Area 6—CENTRAL PLAINS SOILS

This area is made up primarily of two major groups of soils: (1) Dark Colored Topsoils; (2) Light Topsoils.

The characteristics of these two groups of soils are similar to those in the Northern Plains Soils area except that they have more sand and carbonates. The soil in this area was derived from more recent geological material.

Eastern Laramie County is a dryland farming area—mostly winter wheat. Irrigated land is found along the Platte River, the Wheatland area, and in southeastern Laramie County. The water for irrigation in southeastern Laramie County is pumped from relatively shallow wells. The major use of the area as a whole is range land.

MISCELLANEOUS

As a matter of interest, but no great significance, there are a number of active sand dune areas in the State; one area is located east of Eden, another one east of Lamont, one northeast of Casper, and one in Goshen County.

There are also sizable areas of scoria in northwest Campbell County and in adjoining areas of Sheridan and Johnson Counties. These "clinker" beds are thin-bedded shales, fused into porcelomite by heat from burning coal beds.

HISTORY OF LAND USE

The first crops harvested from our Wyoming land were furs, hides, wild meat, fruits and nuts for food, clothing and shelter. These provided for the basic needs of the Indians until the white man practically eliminated the fur-bearing animals and buffalo to supply the demand for furs and buffalo robes. Elk, deer and antelope were plentiful and supplied a large part of the diet for early travelers, railroad construction crews, and settlers in Wyoming.

The wildlife crop is now managed by the State Game and Fish Department under a program designed for sustained production. Their management practices include those affecting the food needed by wildlife, which is grown in the soil.

Grasslands

Grass is one of Wyoming's most important crops. Early travelers, however, looked on the plains merely as a forbidding place to cross on their way west. This viewpoint is often shared by our modern tourists.

It was soon discovered, however, that the grass, shrubs and browse in Wyoming's country provided highly nutritious food for all kinds of domestick livestock as for wild game.

In the 1840's and 1850's, tens of thousands of cattle were driven through Wyoming along the various immigrant trails but only a small proportion of them remained in Wyoming. There was a gradual increase in cattle numbers until the 1880's when the enterprise reached boom proportion. By 1885 the number in many areas had outgrown their feed supplies. The very severe winter of 1876-77, plus the lack of feed and water, resulted in a crippling loss of livestock, particularly by the large operators. The lessons learned during this period pointed the way toward better resource management in the livestock industry (Larson, 1965).

Most ranchers are now using soil and range surveys that are available to them and planning the use of these resources in a more scientific manner.

Cropland

There was some farming in connection with ranching operations during the 1860's and 1870's but was confined argely to hay production under irrigation. In spite of strong public and private efforts to encourage farming, it was not until about 1900 that there was any appreciable increase in either irrigated or dryland farming.

In addition to the encouraging results of private irrigation in the Bighorn Basin, the passage of the Carey Act of 1894 and the Reclamation Act of 1902 spurred efforts toward development of irrigation farming along the various rivers and streams throughout the state. The principal irrigated crops are, hay at the higher elevations, and beets, beans, alfalfa, corn and feed crops in the lower elevations.

During the struggle for land and available water, little thought was given to the character and capabilities of the soil. As a result, many mistakes were made in the selection and management of the soil and water resources. New areas considered for irrigation are now being subjected to a thorough study of their soil capabilities and hazards under irrigation.

Dryland farming is confined largely to the Dark Colored Soils along the southeastern edge of the State and in smaller areas around Gillette, Sheridan, Saratoga, Cokeville, Star Valley and Alta. Many of the earlier farmers were doomed to failure due to lack of knowledge of the soil and climatic conditions plus over-optimistic promotional information and the limitations of the Homestead Act. Many of the early homesteads, especially in the Light Colored Soils area in eastern Wyoming, had to be abandoned or sold. To relieve the plight of the farmers in Converse, Campbell and Weston Counties, the U. S. Government initiated a land purchase and resettlement program. The government bought the land, reseeded it to grass and leased the grazing privileges to neighboring ranchers.

Present day farmers are making use of the latest information on soil capabilities and have in general established sound resource management and stabilized the industry. The principal dryland crop is winter wheat, along with feed grains and some corn.

Woodland

The use of woodland areas started early in Wyoming history with the harvesting of trees for lumber and ties. These activities are continuing and there are opportunities to further develop the production of forest products.

A selective timber crop harvesting program which leaves a protective cover on the soil is an essential part of a good watershed program. It helps control the runoff from rains and provides for the gradual release of water from the melting snowpack. This continuous supply of water throughout the year not only reduces flood hazards but is highly important in providing good water for domestic, industrial and agricultural uses.

The forested areas of Wyoming provide excellent wildlife habitat and offer many opportunities for projects that will help satisfy the rapidly increasing demand for various types of recreational uses.

Wildlife and Recreation Lands

Much of our Wyoming land is multi-purpose land. It is capable of providing a number of uses. Wildlife is abundant on the farms and grasslands as well as in the forests. Outdoor recreation activities (hunting, fishing, camping, horseback riding, hiking, etc.) can be found on farms and ranches as well as in the forest and parks. All of this is big business in Wyoming and will get much bigger. An inventory of present recreational enterprises and an analysis of potential development on both private and public lands is now being made.

The distribution of the irrigated and dryland areas in Wyoming is shown in Fig. 12.

SOIL CONSERVATION PROBLEM

The productive capacity of Wyoming soils (Fig. 13) can be reduced or lost in a number of ways such as:

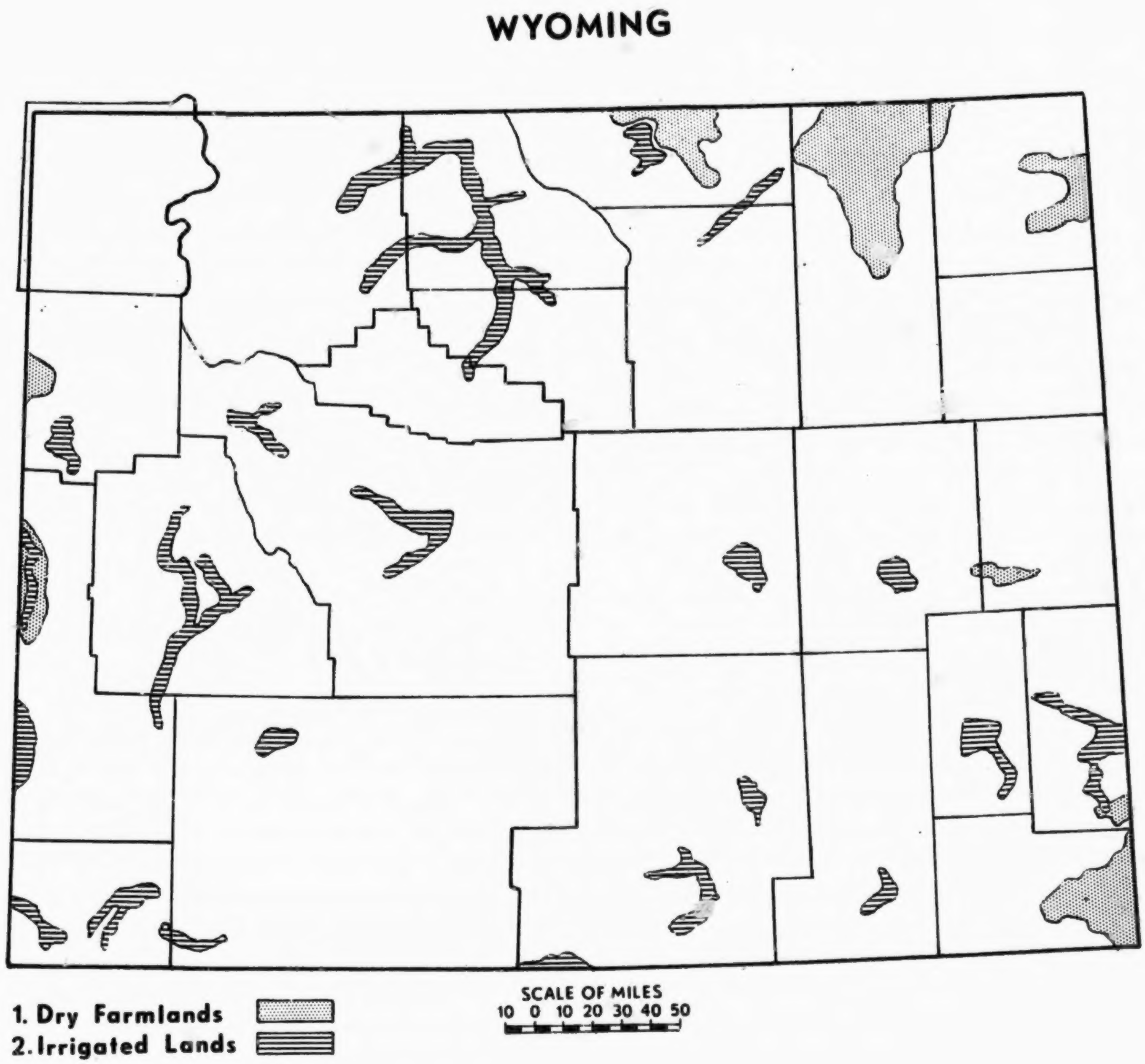

Fig. 12. Wyoming's cultivated lands and their location.

1. Deterioration in physical condition—a soil may loose its desirable physical structure by longtime cultivation or erosion. A change in texture usually accompanies the deterioration of soil structure primarily as a result of erosion by either wind or water.

2. Plant nutrients—plant nutrients may be reduced or removed through cropping, erosion and backing.

3. Seepage, accumulation of salts, and weeds.

Soil losses in Wyoming are being controlled and productivity maintained (Fig. 14) and, in many cases, improved by applying well planned conservation practices such as:

1. Proper land use based on soil survey information.

2. Crop rotations to help maintain or improve soil structure.

3. Wind strip cropping, stubble mulch tillage, rough tillage, and shelter-belts to control erosion by wind.

4. Controlled grazing, rotation and deferred grazing, stock water developments, fire protection to improve the productive capacity of the range, and to provide a good soil cover to lessen run-off and erosion.

5. Contour strip cropping, stubble mulch tillage, and terraces to control erosion by both wind and water.

6. Water management practices including controlled and timely application of the proper amount of irrigation water, for optimum production, to control loss of nutrients through leaching, prevent erosion, water logging, seepage and the accumulation of harmful amounts of alkali. Good water management is aided by the use of water measuring devices, proper types of irrigation systems, good irrigation structures, ditch lining, drainage, land leveling, and diversion ditches and dikes.

7. Forest and woodlands are being protected for watershed purposes, timber products, grazing for wildlife and livestock, and for recreation purposes, by restricted use of areas, selective and su-

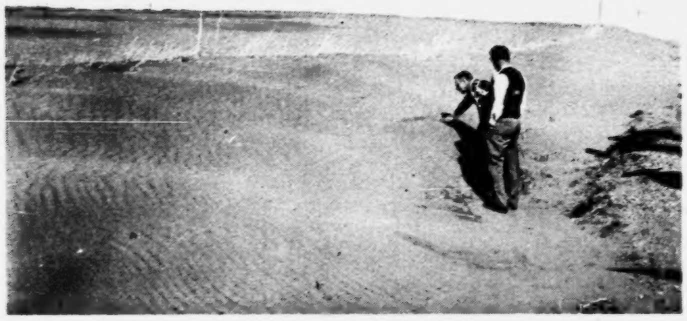

Fig. 13. Wind Erosion—Not only were crops blown out, but a good part of the productive topsoil now covers fences, fills ditches and covers roads. No doubt during the storm dust caused other damages and created health and driving hazards in the community (SCS photo).

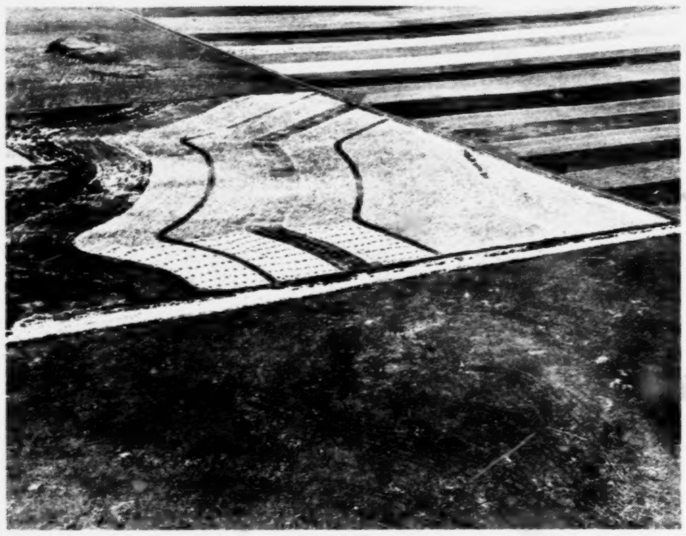

Fig. 14. Erosion Control Measures — Erosion can be controlled and moisture conserved by properly installed conservation practices. The newly planted windbreak, contour stripcropping and the wind stripcropping on this dryland farm are good examples (SCS photo).

pervised timber harvest, insect and fire control, and erosion control measures.

8. Noxious weeds and other types of vegetation are controlled through the use of selective chemical sprays and intensive cultivation.

9. Replacement or addition of plant nutrients in irrigated soils, through use of commercial fertilizer. Most of Wyoming originally had a good supply of mineral elements but due to heavy cropping and leaching, much nitrogen and considerable phosphorus has been used or lost. Hence, for satisfactory production, the use of nitrogen fertilizer, and in many areas phosphorus fertilizers, are added to the soil of irrigated haylands and cash croplands. To determine the kinds and amounts of fertilizer needed, a soil analysis should be used as a guide. A soil analysis may be obtained through local county agricultural agents.

Commercial fertilizers are seldom effective on drylands as soil moisture is usually the limiting factor.

Farmers and ranchers own, use and manage the soil to produce the crops necessary to satisfy human needs for food, fiber and shelter. In addition to our need for agriculture land, there is an ever increasing demand for land uses for housing, highways, parking lots and industrial development.

Well planned scientific resource management is essential to full community development and is therefore everybody's business. Educators, business and professional people, service clubs, politicians, women's clubs, etc., usually cannot deal directly with conservation management measures, but they, along with the land users, can help plan and carry out cooperatively developed ideas and projects for the best interests of the entire community. These activities will vary by communities, but should include such projects as conservation education for both adult and youth groups, land use, soil and water conservation problems in connection with housing development, highways, industrial sites, playgrounds and other recreational areas.

Housewives, business people, professional people, in fact all people, not only have an interest but also share a responsibility in the proper use and management of this resource. Generally speaking, farmers and ranchers try to abide by proper land use and apply needed conservation measures. This is not always easy or sometimes even possible, as the total land use and management problem becomes involved in general economic, educational, scientific and sociological problems. These problems as they affect land management belong to the entire community and not just to the farmers and ranchers alone.

Acknowledgments

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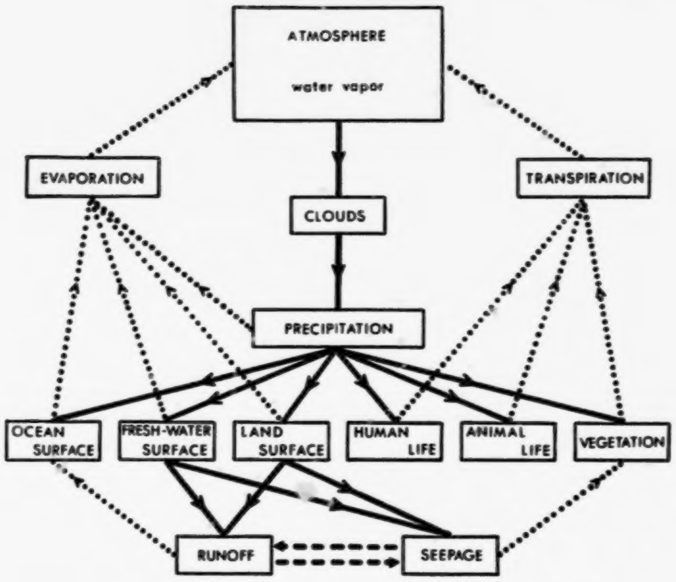
Water Dynamics

PAUL A. RECHARD[11]



THE HYDROLOGIC CYCLE

Fig. 15. Schematic Hydrologic cycle.

Within the hydrologic cycle (Fig. 15), precipitation is the portion that brings water within the scope of man's utilization. Because of this fact, Wyoming's weather is of paramount importance. The general climate of Wyoming is determined by its latitude and distance from the oceans, with local variations in climate being governed by outstanding physical features of diverse landscapes.

CLIMATE

Wyoming's climate is semi-arid with high mountainous areas providing pockets that could be called subhumid. The annual precipitation varies widely across the State, from a low of 5 inches in the Red Desert and lower Big Horn Basin to as much as 45 inches in the Snowy Range and Absaroka Mountains. "Typically" the average ranges between 10 and 15 inches in the inhabited areas of the State. The seasonal precipitation pattern, east of the Continental Divide, is characteristic of high plains regions with the bulk of the precipitation occurring during the spring and summer months. Most of the moisture west of the Divide and in the mountains falls in the form of snow, particularly during February and March.

Wyoming is in the latitudes of prevailing westerly winds which are much more predominant during the winter than during the summer. In the winter much of the moisture in the air is precipitated over the numerous mountain ranges between the West Coast and Wyoming. Enough of the precipitable water remains, however, to cause precipitation on the western slopes of Wyoming mountain ranges, leaving a much smaller portion for the eastern part of the State.

As the predominance of the prevailing westerlies decreases in the spring, circulation patterns occur, bringing moist air to Wyoming from the Gulf of Mexico. Air flow from the Gulf is upslope and this lifting and cooling of the air provides eastern Wyoming with late spring moisture. Cold air masses moving southward from Canada and wedging under the warmer moist Gulf air, or convective activity due to ground surface heating by the incoming radiation of the sun (greater during spring than winter) also provide the lifting and cooling action.

Precipitation patterns are indicated on maps by means of lines called "isohyets" connecting points of equal precipitation (Fig. 16). Also indicated is the seasonal distribution at selected stations. The height of the bar represents quantity and the numerals tell the number of the month of maximum or minimum precipitation.

There are very few days during the year when the sun does not shine at least part of the day in Wyoming. Of the daylight hours when it is possible for the sun to shine, Wyoming typically has clear skies approximately 55 percent of the time in the spring and early summer, and 75 percent of the time in the fall, with 65 percent being an average throughout the year.

The mean elevation of the state is about 6,700 feet above sea-level and at such elevations temperatures seldom reach 100°F. The warmest parts of the State are at the lower elevations in the Big Horn Basin, and along the east-central and north-central borders of Wyoming.

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[11] Director, Water Resources Research Institute, University of Wyoming.

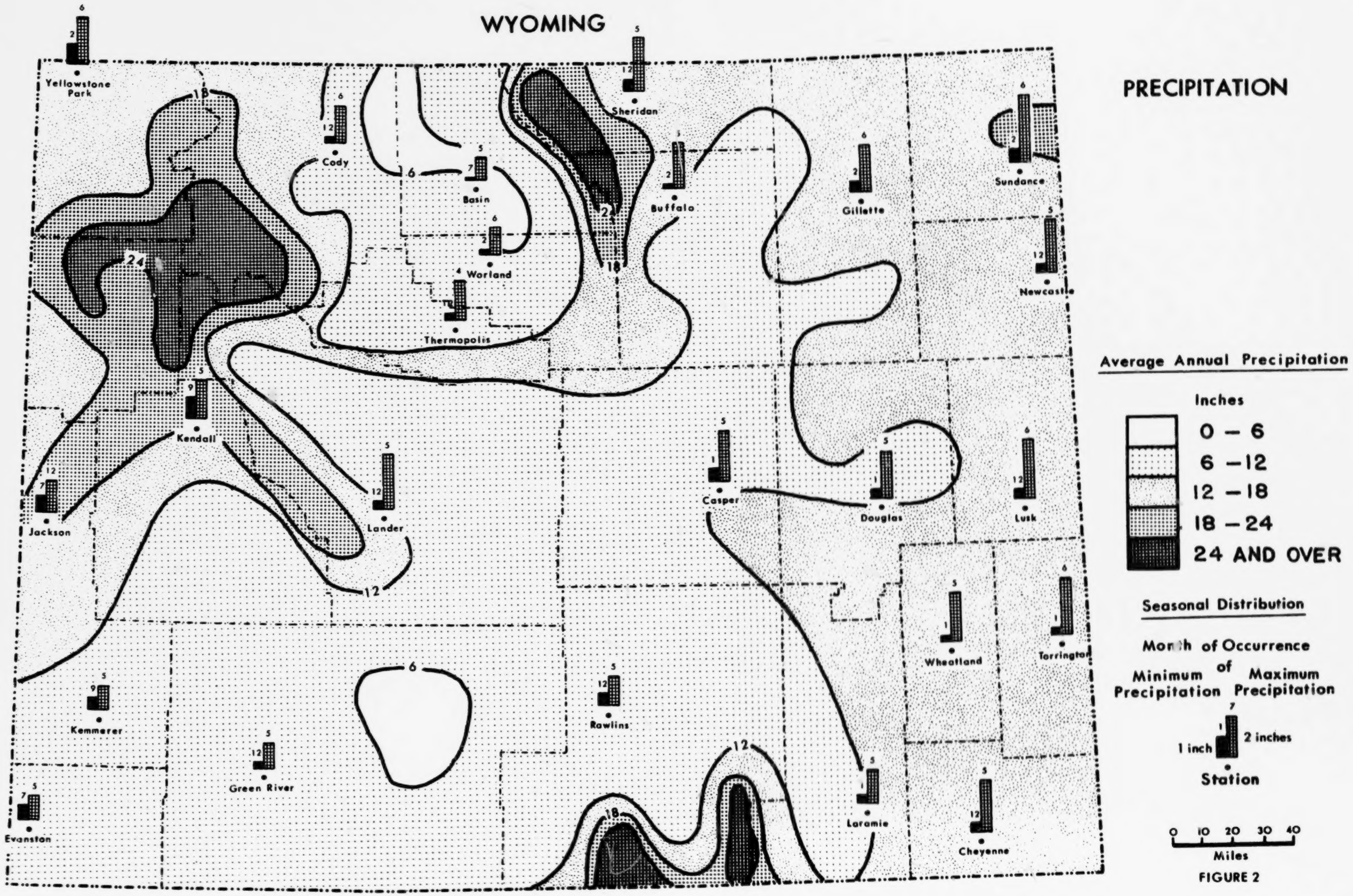
WYOMING
PRECIPITATION
Average Annual Precipitation
Inches
0 – 6
6 – 12
12 – 18
18 – 24
24 AND OVER
Seasonal Distribution
Month of Occurrence
of
Minimum Precipitation
Maximum Precipitation
1 inch
2 inches
Station
0 10 20 30 40
Miles
FIGURE 2
Yellowstone Park
Cody
Basin
Worland
Thermopolis
Sheridan
Buffalo
Gillette
Sundance
Newcastle
Kendall
Lander
Jackson
Casper
Douglas
Lusk
Wheatland
Torrington
Kemmerer
Rawlins
Green River
Evanston
Laramie
Cheyenne
6
12
18
24

Fig. 16. Isohyet precipitation pattern for Wyoming and seasonal occurrence of maximum and minimum precipitation for selected stations.

For most of the State's non-mountain stations, July mean maximum temperatures range between 85°F and 90°F. Throughout the State, summer nights are almost always cool, typically 50°F to 55°F, since outgoing radiation is very rapid from the surface through the dry, thin air. Fluctuations of 30°F to 35°F between the maximum and minimum daily temperatures are common. Rapid and frequent temperature changes are also the pattern in the wintertime.

Usually fewer than 10 cold waves in Wyoming occur during the winter, with the majority of the stations recording less than half that number. Most of the cold air masses from Canada tend to move southeasterly and later easterly in these latitudes. Consequently even those areas of Wyoming east of the Big Horn Mountains and east of the Laramie Range are seldom in the cold Canadian air masses for more than a few days.

Temperatures in Wyoming typically rise to above freezing in the daytime on more than one-half of the days in January, the coldest month, and drop below 0°F on only a few calm, clear nights during the winter.

Many locations on the leeward side of mountain ranges reap the benefit of the downslope effect on the winter winds. The heating of the air associated with the downslope flow, or Chinook, results in low average values of relative humidity and in a rapid dissipation of snow cover on the plains. Although considerable snow falls on the plains each year, they are seldom covered with snow for more than one or two weeks at a time, even in the middle of winter. Thus, the relative consistency of the wind in Wyoming is truly beneficial for it minimizes the disruption of services and the other inconveniences sometimes caused elsewhere by heavy snowfalls. In addition, the cooling breezes of summertime provide a very effective natural air conditioning.

A large part of the precipitation, especially that which falls in the form of rain, is used to partially satisfy the needs of vegetation. The term used to describe the amount of moisture used by plants and transferred from the earth's surface to the atmosphere from the plants and the surrounding ground is "evapotranspiration". The term is derived by combining evaporation and transpiration. Another word often used synonomously is "consumptive use". The amount of evapotranspiration that would take place if there were always enough moisture in the soil for the use by vegetation is called "potential evapotranspiration" (PET). A map of Wyoming showing the annual amounts of PET is presented in Fig. 17 *(U. S. Weather Bureau and Soil Conservation Service, No Date)*.

It is interesting to compare the isolines of PET (Fig. 17) with the isolines of Precipitation (Fig. 16). From such a comparison it is obvious that in most of Wyoming there is not enough precipitation to satisy the possible utilization by vegetation. Fortunately, the precipitation accumulates as snow during the winter at the higher elevations with the result that the potential evapotranspiration is more than fully met in those areas. This emphasizes the importance of snow in the water economy of the State.

WATER RESOURCES

General Features

Wyoming is in the favorable position of being on the headwaters of four of the major drainage basins in the United States. The Green and Little Snake Rivers in southwestern Wyoming are important parts of the headwaters of the Colorado River. The Bear River, along the western boundary of Wyoming, is a major contributor to the Great Salt Lake. The Snake River from Jackson Hole, joined by the Salt River from Star Valley flows westerly across Idaho to swell the Columbia River. The rivers in the remaining 76 percent of the area of the State make their contributions to the Missouri River Drainage Basin.

Of particular interest is the Great Divide Basin or Red Desert, located along the Continental Divide in the area between Rawlins and Rock Springs, Wyoming. This basin is closed, having no drainage outlet to the ocean.

In Table 2, the area of the several drainage basins in Wyoming are presented.

Table 2. Land area of the drainage basins of Wyoming

	STREAM BASIN SQUARE MILES	PERCENT OF STATE
Missouri River (including 4,000 sq. mi. in Red Desert)	74,023	75.6
Colorado River	17,135	17.5
Columbia River	5,287	5.4
Bear River	1,469	1.5
Total	97,914	100.0

Approximately 75 percent of the streamflow of Wyoming originates as snowmelt on the several high mountain ranges where the natural process of storing snow during the winter and early spring for release as water sometime during the growing seasons provides an impoundment system that could only partially be duplicated by man and at great expense.

Based on the records of streamflow that are available, Wyoming's streams produce a mean annual runoff of 15 million acre-feet[12]. Of this amount, Wyoming is now using consumptively 2.5 million acre-feet leaving approximately 12.5 million acre-feet to flow across the border (Fig. 18) (U. S. Senate, 1960).

The precipitation not returning immediately to the atmosphere or finding its way to the streams, sinks into the ground. In many instances, this "ground-water" provides another "source" for municipal, industrial and agriculture use. Ground water reservoirs are not visible, thus their use potentials are not as apparent as those of surface waters. Considerable work, however, has been done by ground-water hydrologists[13], to indicate possible areas where, because of water and geologic structure, use of the ground water might be developed in Wyoming (Fig. 19). The quantity of water available in specific areas is a matter for detailed determination and cannot be indicated as readily on the map *(Water Resources Research Institute, 1966)*

WATER RIGHTS

The Wyoming Constitution provides the foundation upon which water rights are granted in the following Sections:

Article I, Section 31: "Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the State, which, in providing for its use, shall equally guard all the various interests involved . . ."

Article VIII, Section 1: "The water of all natural streams, springs, lakes, or other collections of still water, within the boundaries of the State, are hereby declared to be the property of the State."

Article VIII, Section 3: "Priority of appropriation for beneficial uses shall give the better right . . ."

Wyoming, therefore, through its Constitution, says: (a) the water belongs to the State; (b) water is of such importance that its use must be controlled by the State; and (c) the person first putting the water to beneficial use should be protected. A water right is a license or permit to use the water belonging to the State in a beneficial manner. The right to use water can be termed a property right; however, ownership of a right does not carry with it the ownership of the water involved. The laws of Wyoming specify that beneficial use is the basis, the measure, and the limit of a right.

Basic Theory

There are two theories of water rights prevalent in the United States, riparian and appropriative. A riparian right is the right of an owner of land that borders a natural stream or lake to take water from that source for use on his contiguous, or riparian land. Such a right exists solely by reason of the location of land with respect to the water supply, provided such use of the common supply is reasonable in relation to like rights of use of all other downstream riparian land owners. The riparian theory goes back at least as far as Roman Civil law. The riparian theory, so common in the Eastern United States, was declared invalid by the Wyoming Constitution.

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[12] There are several units used when discussing the amount of water. The term "acre-foot" means the amount of water which would cover one acre of land one foot deep. Another unit frequently used is "cubic foot per second," or "second-foot." The term refers to one cubic foot of water passing a given point in one second, and is a measure of the rate of flow, while acre-foot is a measure of volume. One cubic foot per second flowing continuously for 24 hours equals approximately two acre-feet. Less frequently used in measuring flow is the unit known as the miners' inch. This term comes from the use of water by gold miners in the early days of the development of the West. In most states 50 miners' inches equal one cubic foot per second. For industrial and domestic use, we generally use the units of gallons and gallons per minute. Roughly, it takes 450 gallons per minute to equal one cubic foot per second.

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[13] The study of the water cycle and its component parts is called Hydrology—(hydro — water + logy — knowledge of) the study or knowledge of water.

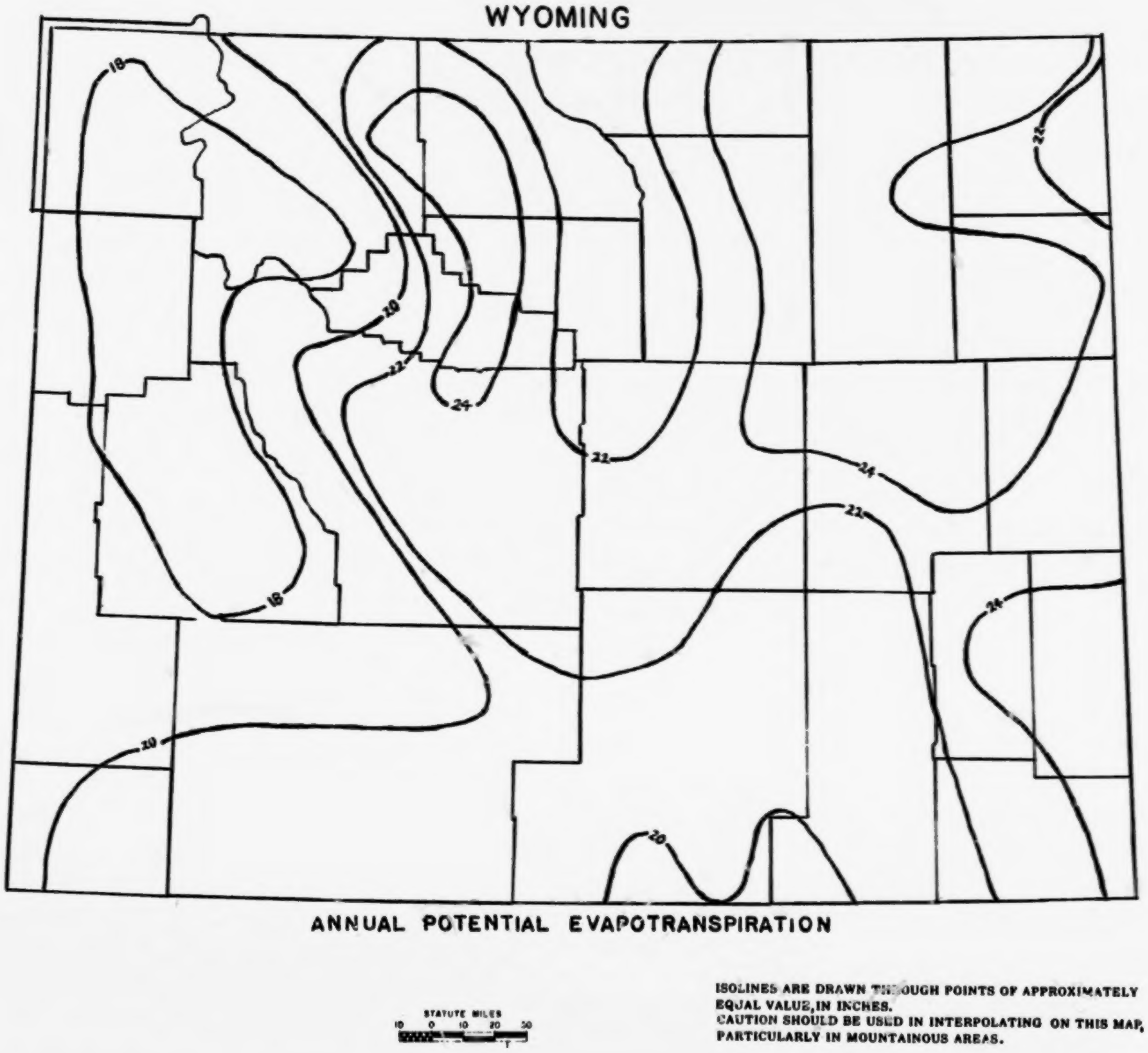
WYOMING
18
20
22
24
ANNUAL POTENTIAL EVAPOTRANSPIRATION
STATUTE MILES
10 0 10 20 30
ISOLINES ARE DRAWN THROUGH POINTS OF APPROXIMATELY EQUAL VALUE, IN INCHES.
CAUTION SHOULD BE USED IN INTERPOLATING ON THIS MAP, PARTICULARLY IN MOUNTAINOUS AREAS.

Fig. 17. Potential evapotranspiration isoline patterns for Wyoming.

The appropriative right, embraced by Wyoming, is not based upon the location of the land, but is based upon work done in putting the water to beneficial use, regardless of where the land might be on which the use is made. Each appropriative right has a date of priority effective as the time application is made to the Wyoming State Engineer for a permit to use the designated water. This priority gives preference in the use of water to the earlier rights, when the supply is not enough for all. This theory of prior appropriation developed through the customs of gold miners in California and thus truly has its source in western development. *(Trelease, 1965.)*

A direct flow appropriative right, that is a right to use the water flowing in a natural stream, is perfected by applying that water to irrigation or to some other beneficial use on or in connection with a particular tract of land. This becomes the place of use to which the water right relates and attaches. Wyoming law prescribes that a person acquiring a direct flow right may divert up to one cubic foot per second for each 70 acres of land irrigated. For other beneficial uses, the amount of the diversion must be stated in the permit. There is no period of use of water except the provision that the water must be applied to beneficial use. Likewise, there is no upper limit in total annual quantity of water for direct flow use unless so specified in the permit.

A right to store water is limited to the authorized capacity of the reservoir in any one year and the water thus stored may be used for beneficial purposes as specified in the storage water right.

Preference of Use

The Wyoming statutes set forth a preference for use of water. The highest use shall be for drinking purposes for both man and beast; second is water for municipal purposes; third, steam engines and general railway use, culinary, laundry, bathing, refrigerating, heating plants, and steam power plants; and fourth is water for industrial purposes. The Statutes also provide that water for irrigation shall be superior and preferred to hydroelectric power production.

The difference between preferred use and priority of use deserves emphasis. Anyone propos-

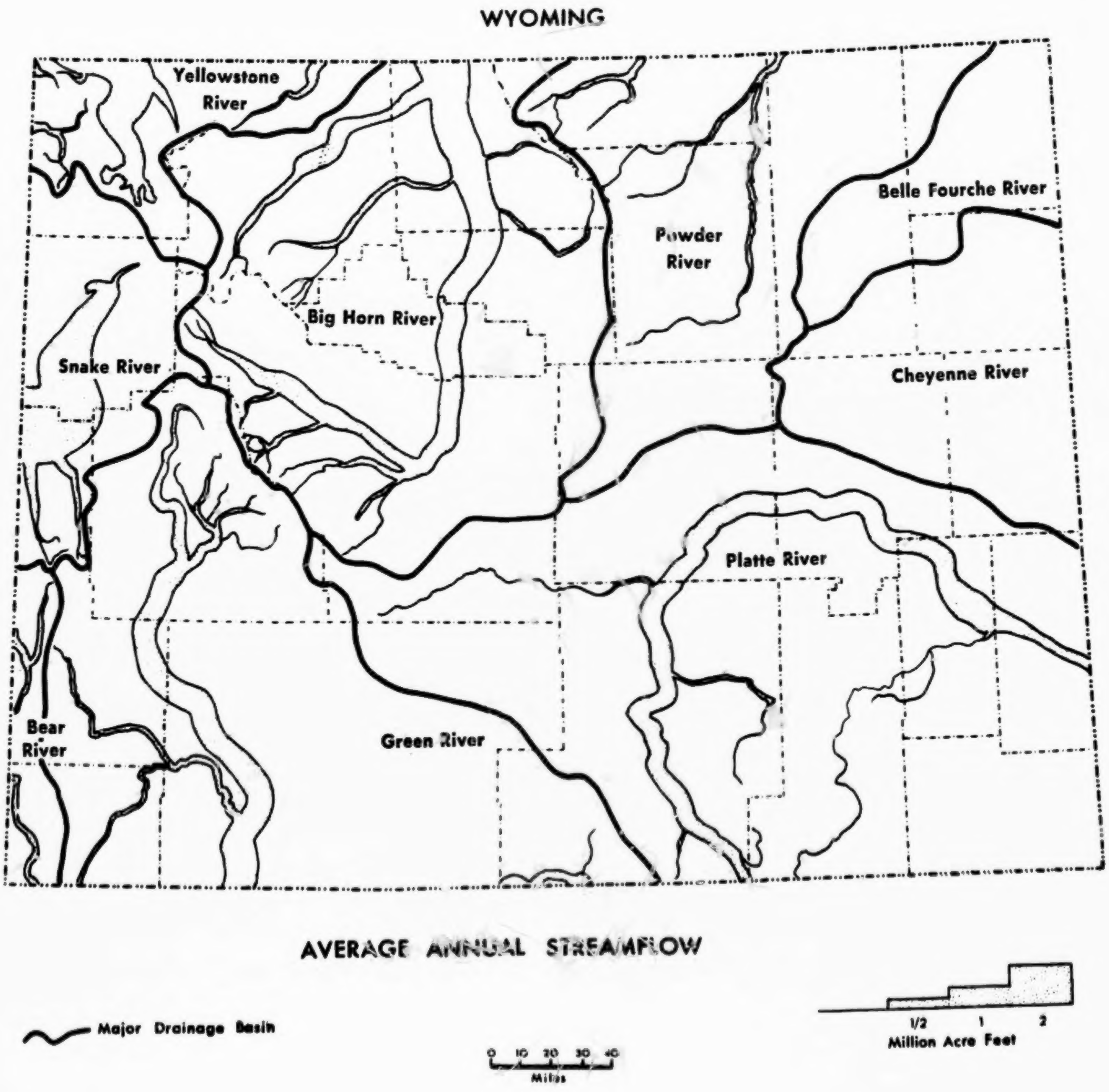
WYOMING
Yellowstone River
Powder River
Belle Fourche River
Big Horn River
Snake River
Cheyenne River
Platte River
Bear River
Green River
AVERAGE ANNUAL STREAMFLOW
Major Drainage Basin
0 10 20 30 40
Miles
1/2 1 2
Million Acre Feet

Fig. 18. Mean annual runoff of Wyoming's river drainages.

ing to use water, whether for preferred use or not, must follow the specified procedure and thereby obtain a priority. A use *not* preferred which has a priority *earlier* than a preferred use has the better right. If there is only enough water in a stream to satisfy the first right, and that right happens to be a non-preferred use, that non-preferred use may take the water even though a later priority preferred user receives none. However, that later priority preferred user may purchase the earlier priority and change the type of use to that which is desired. The preferred user may normally obtain by condemnation (which requires that just compensation be paid) an earlier priority. He cannot just demand that water be released to satisfy his needs, if an earlier user is applying that water to beneficial use.

Who May Appropriate Water

A water appropriation may be made by any person under the Wyoming law. Such an appropriation may be made by the United States, the State of Wyoming or any entity or organization capable of holding an interest in real property in the State. It is not necessary that the appropriator shall own outright the land on which the water is to be used. If, however, he does not own the land, he must show the arrangements made with the owner for its control for that purpose.

One who wishes to appropriate water in Wyo-

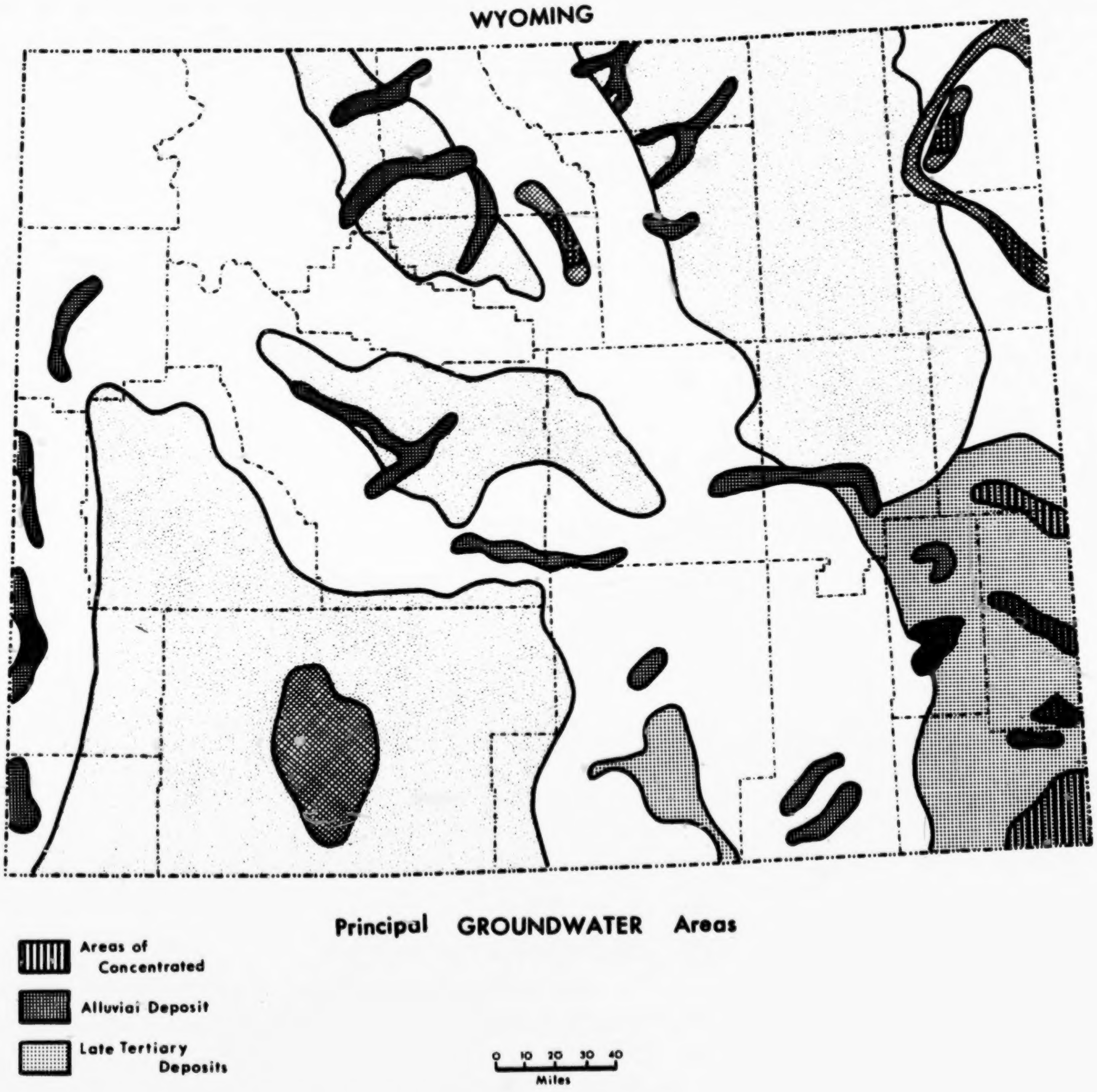

Fig. 19. Location of Wyoming's principal water bearing strata.

ming must follow the procedures prescribed in the Wyoming Statutes and in the regulations of the Wyoming State Engineer. This is true whether the water is wanted for immediate use or for storage, no matter how large or how small the quantity, or for what purpose it is to be used.

As long as the water is used in accordance with the provisions of the permit, or the certificate of appropriation, that water right will remain in good standing. It may be lost, however, by non-use, provided that non-use extends for a consecutive period of five years during which time water was available to satisfy the right.

Interstate Water Rights

There are basically two ways to determine or settle the rights of states which are competing for the waters of interstate streams to those waters; by appeals to the United States Courts, or by interstate compacts. These latter are agreements negotiated by the states dividing the waters of interstate streams. Wyoming's rights to the waters of the Belle Fourche River, the Colorado River (Green River, Little Snake River, and Henry's Fork of the Green River), the Snake River, the Yellowstone River (Clarks Fork of the Yellowstone, Big Horn River, Tongue River, and

Powder River), and the Niobrara River have been settled by interstate compacts. The rights of Colorado and Wyoming to the waters of the Laramie River; of Colorado, Wyoming, and Nebraska to the waters of the North Platte River; and the rights of Wyoming and Idaho to the water tributary to the Teton River have been established by decrees of the United States Courts (Lloyd and Rechard, 1957).

Based on the physical characteristics of the streams and their drainage basins, the division of the waters of interstate streams has been accomplished in several ways. The negotiations have utilized percentage allocations of depletions, of stream flows, of divertible flows and interstate priority distribution. Because of the variety it is difficult to present the material contained in the compacts in a concise manner. A review of the documents pertaining to interstate streams reveals that within the allocations provided, approximately 2.5 million acre-feet of water may be consumptively used by Wyoming in addition to an equal amount presently utilized *(Water Resources Research Institute, 1966).*

WATER UTILIZATION

Wyoming need not fear that she will run out of water. With her favorable physical location and due to the foresight of the people, Wyoming has the water to supply her forseeable needs. Wyoming has sufficient water for industrial, agricultural and personal needs for a population of 20 million.

The greatest single use of fresh water in Western United States is for irrigation. Fifty billion gallons per day are used for this purpose, or about 85 percent of the fresh water consumed annually (Mackichan, 1961). There does not seem to be any indication that this use will diminish, rather it will increase. According to the Department of Agriculture, the changing American diet now includes more animal products, fruits, vegetables and sugar and fewer grain products and potatoes (U. S. Department of Agriculture, 1955). The increase in cropland requirements for food production, because of the inclusion of more livestock products in our diet since the beginning of World War II, is 0.14 acre a person, making a total of 2.5 acres of cropland needed to support each person in the United States. The equivalent of the production of 100 million additional acres may be required by 1975 to meet the requirements of our larger population. Because the land available for new production is limited, the increase in food requirements will be directly associated with the use of water through irrigation and with the planned increase in production on lands now being farmed. Also, it must be recognized that not only will new land be needed for more people, but it will be necessary to replace the 1,800,000 acres being taken out of production every year for cities, suburbs, airports, highways, tree plantings, erosion, etc.

The next largest water consumer in the West is industry and steam power plants. Examples of typical water requirements for industries now in Wyoming or that might someday be located in the state are: 18 barrels of water to refine a barrel of oil; 10 gallons of water to refine a gallon of gasoline; 250 tons of water for a ton of sulphate wood pulp; and 600 to 1,000 tons of water for each ton of coal burned in a steam power plant. A large paper mill uses more water each day than does a city of 50,000 inhabitants.

The data available for several western cities, including Denver, Los Angeles and a number of smaller cities, show diversion requirements for municipal use will generally be about one acre-foot, for from five to eight persons. This diversion rate provides for all water requirements, including industrial uses. The Public Health Service reports an average water requirement of 180 gallons per capita per day for cities of 10,000 population or more.

The first and highest use of water, is for human consumption, and next for domestic animals. Following this well-recognized preference of use for sustaining human and animal life, conflicts frequently arise, about uses of water. Demands for up-valley irrigation may conflict with down-stream needs for navigation or power development, or with requirements for mining and industry. Wildlife interests want ample habitats for nesting birds, while agriculturists may want to drain land for pasturage and crops. Many citizens feel that the recreational use of water should have more attention. The increasing demand for water will, in many cases, demand changes in use and in the laws concerning use.

History of Irrigation

In the early years of Wyoming's settlement it was not necessary to keep records of the use of water; therefore the date of the first irrigation development is not known precisely. It is probable that irrigation began about 1853 along Blacks Fork, a tributary of the Green River, in the vicinity of Fort Bridger. Records show that in 1859, hay was produced in the nearby Henry's Fork valley and sold to the United States Army then stationed at Fort Bridger. It is not known whether this hay was grown with the aid of irrigation *(Lang, 1956)*.

The first recorded evidence of irrigation development in the files of the State Board of Control indicates that there were 302 acres of land receiving water in 1862. From this early beginning in the southwestern portion of the state, the people of Wyoming have reclaimed about 2 million acres of raw land for productive purposes.

Wyoming's United States Senator Carey inspired considerable irrigation activity by sponsoring and getting accepted by Congress and the President, in August, 1894, the "Carey Act". This Act authorized the Secretary of the Interior, with Presidential approval, to grant each state having desert lands an area not exceeding one million acres of such lands "as the state may cause to be irrigated, reclaimed, occupied, and not less than twenty acres of each 160-acre tract cultivated by actual settlers, within ten years after the passage of this Act." In 1908, Wyoming and Idaho were permitted to increase the area by an additional one million acres. Under the Carey Act, application was made for nearly one million acres of land in Wyoming; however only about ½ million acres of land have been segregated.

The Bureau of Reclamation began construction work on projects in Wyoming in 1904 when Buffalo Bill Dam and Reservoir was started near the town of Cody. The work by the Bureau was in response to requests by officials and residents of the area to carry to completion the dreams and plans of Col. W. F. "Buffalo Bill" Cody and his partner Mr. Nate Salisbury begun in 1899.

Another early project by the Bureau of Reclamation was the North Platte Project along the North Platte River near Torrington. Because of the fluctuations in the natural runoff of the river, storage and regulation were necessary. The first investigations of the area by the Reclamation Service were initiated in 1902 shortly after the signing of the original "Reclamation Act". Construction of Pathfinder Dam in a granite canyon three miles downstream from the mouth of the Sweetwater River, the key to the development of this project, was initiated in 1905 and completed in 1909.

From this beginning the Bureau of Reclamation has been continuously active in the development of the water resources of Wyoming. Reclamation projects provide major conservation areas in almost every portion of the State.

The Corps of Engineers has recently assisted the relatively few areas of the State that have been subject to flooding. Their work in Wyoming has been on the Snake River in Jackson Hole, the Big Horn River near Greybull, and on Goose Creek as it flows through Sheridan.

The Department of Agriculture has, of course, been active in the agricultural development of the entire state. Since the passage of the "Public Law 566" measure this department, in cooperation with the State Soil and Water Conservation Committee, has increased their developmental activities.

Governmental Agencies and Future Development

The Wyoming Constitution recognized the importance of water to the State and in Section 5 of Article VIII created the office of State Engineer with the responsibilities for the "general supervision of the waters of the state and of the officers connected with its distribution". During succeeding years eleven other departments or agencies have interests or responsibilities that are water resource related. These are *(including the State Engineer)*:

1. State Engineer
2. Department of Agriculture
3. Natural Resource Board
4. Geological Survey
5. Recreation Commission
6. Game and Fish Commission
7. Department of Public Health
8. Highway Department
9. Attorney General
10. Commissioner of Public Lands
11. University of Wyoming

Several Federal Agencies have participated with the State and private entities to further the development and utilization of the water resources of Wyoming. These agencies are:

A. Department of the Interior:
   (1) Bureau of Reclamation;
   (2) Bureau of Land Management;
   (3) Geological Survey;
   (4) National Park Service;
   (5) Bureau of Sport Fisheries and Wildlife;
   (6) Bureau of Indian Affairs;
   (7) Bureau of Outdoor Recreation.

B. Department of Agriculture:
   (1) Agricultural Research Service;
   (2) Soil Conservation Service;
   (3) Agricultural Stabilization and Conservation Service;
   (4) Farmer's Home Administration Service;
   (5) Forest Service.

C. Department of Commerce:
   (1) Weather Bureau;
   (2) Bureau of Public Roads.

D. Department of Defense:
  (1) Corps of Engineers.
E. Department of Health, Education, and Welfare:
  (1) Public Health Service.
F. Department of Urban Affairs:
  (1) Housing and Home Finance Agency.
G. Independent Agencies:
  (1) Federal Power Commission;
  (2) Interstate Commerce Commission.

Two of these federal agencies observe, collect, and distribute basic information about the water resources of Wyoming and the nation.

The United States Weather Bureau (USWB) is the principal agency involved in maintaining records of precipitation, temperature, and the rate of evaporation.

The United States Geological Survey (USGS) is the major agency involved in measuring the amount of water flowing in our streams. In most states this stream gaging program is financed on a cooperative basis, that is, the state furnishes half the money, with the Federal Government furnishing the other half. Stream gages are established at various locations and for various reasons. Usually the location is selected for general hydrologic information of interest to many people. Sometimes, however, it is selected to obtain information at a specific point such as at a proposed dam site. Also, gages are established at points on a stream to assist in the administration of water rights.

The U.S.G.S. also gathers data concerning the location and availability of ground water and the quality of both the surface and ground water.

The information gathered by the Weather Bureau is published for each state on a monthly basis and is known as "Climatological Data", and the stream gaging records are published annually by the Geological Survey in what they term "Water Supply Papers".

Future Development

Further regulation of streams by storage may take care of a large part of our expanded needs, but such regulation will not solve our water problems. There are vast areas of undeveloped groundwater storage that, if scientifically mapped and managed, could possibly double the existing withdrawal from groundwater reservoirs. Corrective measures must be taken where overdraft of our ground water exists. Good soil conservation practices and proper forest and grass cover will increase the availability of water, particularly its distribution throughout the year. The possibility exists to reduce the evaporation losses, principally along our stream valleys, by the elimination of heavy water-using vegetation where the plants are not required for shelter or other useful purpose.

A bright spot in Wyoming's future is the potential tourist business. The State contains vast areas capable of supporting a tremendous number of recreationists in a manner that will expand and enhance the economy. The prime factor in full development of this potential, in competition with other western states, is water. The existing supply of natural lakes and streams in a relatively non-commercial state offers the opportunity to capitalize upon this natural resource merely through protection and wise utilization. This type of "use" is mainly nonconsumptive, and sound planning can provide for a considerable amount of multiple benefit.

The usability of the State's water depends on its quantity, quality, time of occurrence, and legal stipulations. The Federal Government has become very active in the quality of water field in recent years. Wyoming, as a headwater state, does not have industrial pollution problems to the extent of many states, yet the state must keep ever alert to assure the wellbeing of all of its citizens. Also, the combination of some of the geology with the semi-arid nature of Wyoming does cause large changes in water quality which can and do contribute problems for some irrigation and municipal supplies.

Examples of the trend towards the future can be found in the north-central portion of the state in the vicinity of Buffalo and Sheridan and in the western part north of Green River. In the early 1950's, Reynolds Metal Company saw possibilities of utilizing some of the vast deposits of Wyoming coal for the generation of large amounts of electricity which are a necessity to the aluminum industry. The prospects of development were bright enough for the company to purchase considerable acreage of land in the area around Lake DeSmet Reservoir and the water rights for the reservoir itself. Pending the time when the company feels it advantageous to complete their development, their lands are being operated as a ranch and the water excess to their needs is sold to other ranches along Piney Creek.

Even though it is the only instance in the state to date, a far reaching step was taken towards the development of Wyoming when the State of Wyoming through the Natural Resource Board, purchased 60,000 acre-feet of storage space in Fontenelle Reservoir in Western Wyoming. This reservoir has been constructed by the Bureau of Reclamation primarily to regulate the flows of the Green River and to provide a diversion structure for the Seedskadee Irrigation Project. Prior to its construction, the state contracted with the Bureau to pay for increasing the height of the dam a sufficient amount to provide an additional capacity of 60,000 acre-feet. The cost of this additional space was inexpensive and it is now available for purchase by industries when they choose to establish themselves in that area.

The future of water resource utilization in Wyoming is extremely bright. To capitalize on the bounties nature affords us, we must have more knowledge, better engineering, and the increased consideration of complicating factors on the part of all water users.

Acknowledgments

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Grasslands

MORTON MAY[14]

Grasslands interpreted in the strictest sense as "lands where grasses dominate", would actually include only portions of the state where grass species are the prevailing plants (Huss, 1964). This strict definition of grasslands would exclude many of the more productive grazing regions which are dominated by woody species interspersed with grasses and forbs. In the West, lands which support livestock grazing are termed "rangelands". Rangelands are defined as "lands, where present soils and climate, in conjunction with plant succession, produce natural pastures" (Dyksterhuis, 1966). The resulting natural pastures are grazing areas which maintain and perpetrate themselves without the use of cultural practices and would include grasslands, shrublands, grazable forest lands and alpine forb communities. Wyoming's rangelands are vitally important to the livestock industry from which the state derives a large portion of its annual income. For example, cash receipts from livestock and livestock products in Wyoming averaged over 126 million dollars per year during the years 1959 through 1963 (Wyo. Agr. Exp. Station, 1965). This annual income to the state does not include the other obvious economic benefits derived from the rangelands such as wildlife production, watershed values, recreation and aesthetic values. Since all grazing areas, whether dominated by brush, forbs or grass, are important they will be included under the general category "grasslands".

On ranges, the soils and the vegetation develop simultaneously and are dependent upon one another. The development of one cannot vary vastly from the development of the other. For this reason, one would naturally expect to find the more productive ranges in areas of well-developed soils. Such is usually the case, as alluvial outwash areas of rich, well-developed soils, and valley and river bottoms usually produce higher forms of vegetation than areas of shallow, undeveloped soils.

Most of Wyoming lies in a transition between the Upper Sonoran zone, which includes the eastern part of the state and the basin areas, and the Canadian zone, which takes in the mountain regions (Cary, 1917). Annual precipitation may vary from six inches or less in the basins to more than thirty-five inches in the mountains. As one travels from the lower to the higher elevations, a definite zonation of plant life is noticeable, with the vegetation being more lush and abundant in areas of high moisture and mature soil development (Darrow, 1944). A complete list of the plant species found in Wyoming, keys for the identification of these plants, major floristic elements and a more detailed description of the vegetation zones may be found in "A Flora of Wyoming" by Dr. C. L. Porter (Porter, 1962, 1963, 1964, 1965).

In Wyoming, as in most of the western states, the lower grazing areas located in the basin regions are referred to as "winter range" and the grazing regions in the higher elevations are "summer range". The lower ranges are grazed for about nine months during the winter. During this period, water is available in the form of snow. These areas are primarily grazed by sheep and various species of big game (Figure 20). Most winter ranges lack water during the summer, and this is one reason for moving livestock into the mountains. During the summer months livestock

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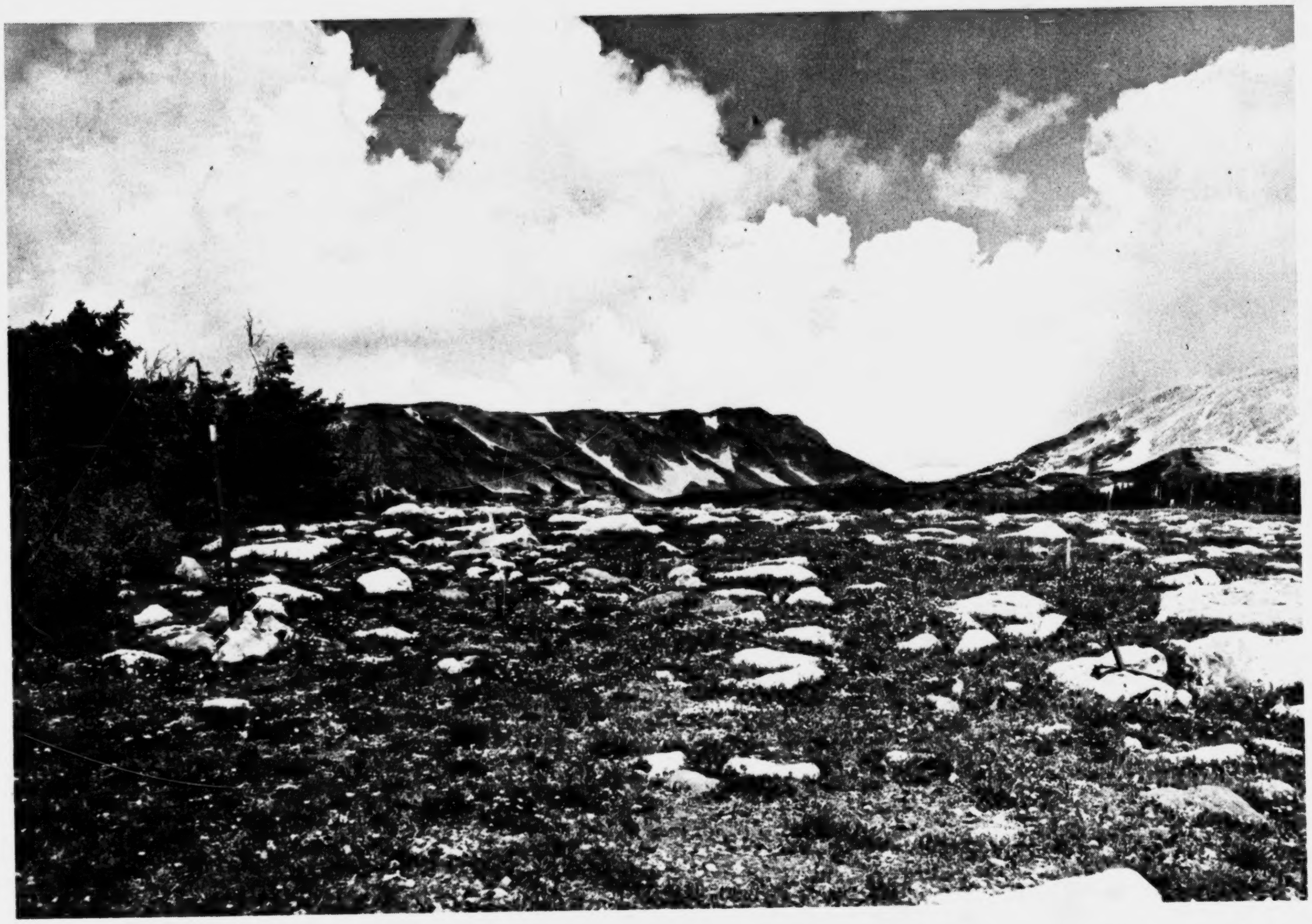

Fig. 20. Typical Wyoming summer sheep range; Snowy Range, Medicine Bow National Forest (U. S. Forest Service photo).

are trailed or trucked into the mountain areas where green, lush vegetation is abundant (Stephens and Utter, 1962). Normally during summer the winter range is rested from grazing and the grass grows, dries, and remains highly nutritious for later use (National forests, 1926). The summer range is grazed by sheep at the highest elevations while the cattle remain at lower altitudes (Beetle, 1956) (Figure 21).

ZONES AND GRAZING REGIONS

Although the grazing areas of Wyoming are scattered at various altitudes, there are some areas which are quite typical of major vegetation types.

Shortgrass Region

The shortgrass range is the western extension of the Mixed Prairie which coincides with the Great Plains. The shortgrass range includes most of the plains areas of Wyoming east of the continental divide. The major plants of this region are blue grama *(Bouteloua gracilis)*, buffalograss *(Buchloe dactyloides)*, western wheatgrass *(Agropyron smithii)*, and needleandthread grass *(Stipa comata)* (Stoddart and Smith, 1955). The shortgrass plains of Wyoming are typical of the shortgrass region that extends from Canada to Mexico. Shrubs and browse species are almost nonexistent and the area is grazed primarily by cattle during the summer or on a year-long basis (Figure 22).

Northern Desert Shrub Region

The northern desert shrub region includes the area known as the Red Desert and the lower elevations of the southwestern and central part of the state. The vegetation is a mixture of grasses, forbs, and shrubs. The important grasses include various wheatgrasses *(Agropyron* spp.*)*, Indian ricegrass *(Oryzopsis hymenoides)*, needlegrass*(Stipa* spp.), and bluegrasses *(Poa* spp.) (Judd, 1962).

Valuable forbs include: winterfat *(Eurotia lanata)*, balsamroot *(Balsomorhiza sagittata)* and Kochia *(Kochia scoparia)* (Riedl, et al, 1964).

Common shrubs include: big sagebrush *(Artemisia tridentata)*, black sage *(Artemisia nova)*,

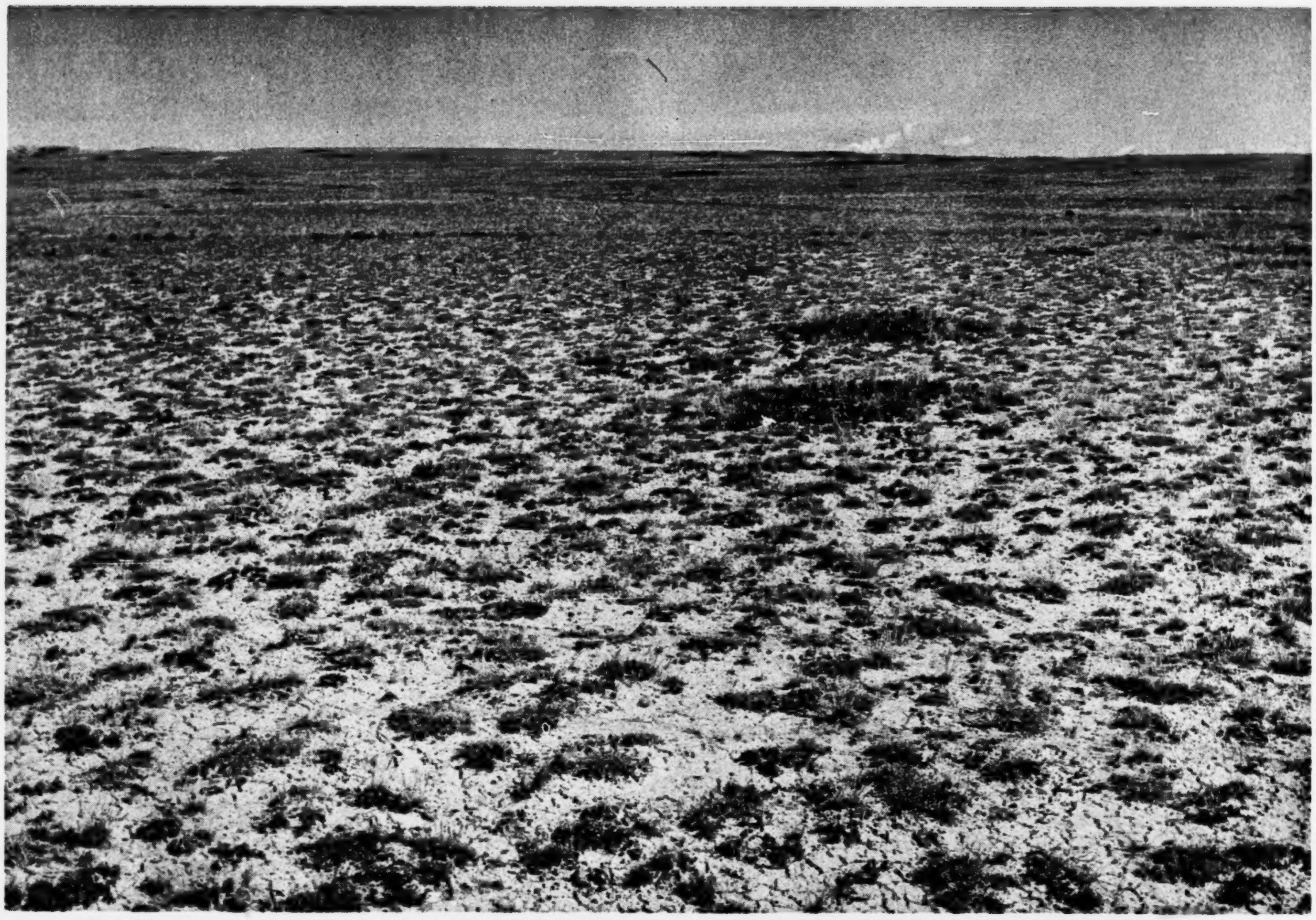

Fig. 21. Typical salt sage sheep winter range of the lower elevations of the Red Desert, Wind River, and Bighorn Basins (Photo courtesy of Dixie R. Smith).

salt sage *(Atriplex nuttallii),* four-wing saltbrush *(Atriplex canescens),* rabbitbrush *(Chrysothamnus* spp.*)* (Gay and Dwyer, 1965). Sagebrush alone dominates over 37 million acres of Wyoming's ranges. Of the seven species of sagebrush found in the state, big sagebrush is the most common, covering over 25 million acres (Figure 23).

Subalpine Meadow (Bunchgrass Region)

The subalpine grassland is one of the most productive grassland areas in Wyoming and occurs mainly in the form of meadows in natural openings known as "parks", at altitudes of 9000 feet to timberline (Figure 24). Important grasses are big bluegrass *(Poa ampla),* Idaho fescue *(Festuca idahoensis),* numerous wheatgrasses *(Agropyron* spp.*)* and bromegrasses *(Bromus* spp.*)* (Judd, 1962). Interspersed in these parks are numerous forbs often exceeding 50 species at one location. The lush wet meadows and streambank areas are composed of a mixture of grasses and sedges *(Carex* spp.*)* often found with stands of willows *(Salix* spp.*).* These wetter areas are usually dominated by tufted hairgrass *(Deschampsia caespitosa)* and numerous sedges.

HISTORY OF USE

Use of Wyoming rangeland for ranching began in the 1870's and corresponded with the large cattle drives during the same period. The development of new markets in the Midwest and the vast expanses of open range available for livestock production led to speculation, growth of large ranching enterprises, and widespread misuse resulting in the deterioration of the rangeland. Speculation and dreams of great fortunes caught on like wildfire in Wyoming as the potential of the rangelands was realized. Cattle numbers in the state increased from 36,000 in 1867 to 779,000 in 1885 (Frink, *et al,* 1956). Although present cattle numbers are greater than during the 1880's, the management has also improved which has allowed for this increased livestock carrying capacity (*Anon.,* 1926.)

There were people who could see what the overstocking was doing to the once nutritious grasslands (Osgood, 1929). Some of the ranch-

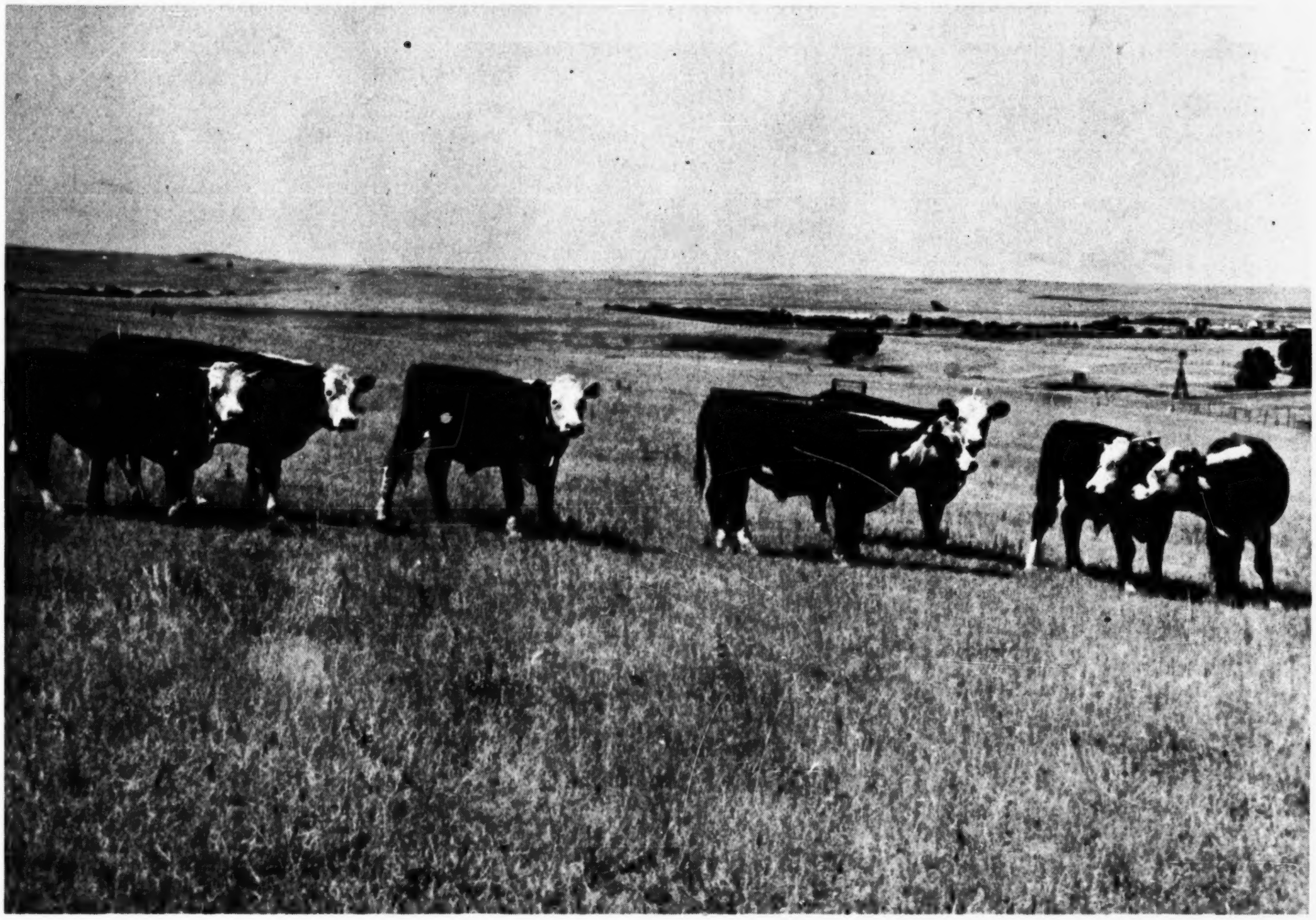

Fig. 22. The shortgrass plains of eastern Wyoming. Note the lack of woody species and the relatively flat terrain (ARS photo).

ers attempted to halt the influx of new cattle by forming associations and restricting further cattle numbers from entering their grazing domain (Frink, et al., 1956.) Overgrazing was not restricted to Wyoming, but plagued other western states as well.

Some of the basic principles of range management were coming into being, and there was little but experience and observation upon which to base them. There were no scientists dedicated to maintaining the grasslands for posterity, but some men would have some close. Witness the statement from Toumey (Toumey, 1891) in 1891 as he referred to overstocking the ranges: "Overstocking kills the better grasses. There is a limit to which any range can be profitably stocked. If we go beyond this limit it will not only be a detriment to the permanency of the range but will be detrimental to the stock as well."

Following the great cattle boom came the sheep industry. Wyoming ranges were very suitable for sheep production and there was plenty of forbs which had escaped excessive cattle use. Both sheep and cattle grazed the winter ranges and moved into the mountains, grazing off the tender plant shoots as the snow melted and retreated up the slopes (*Anon.*, 1926).

These high summer ranges were the scene of some of the first range management and conservation practices. The U. S. Forest Service, concerned with a new trend of conservation sweeping the country during the early 1900's, began to manage the forest lands in such a way as to protect the watershed and conserve the forest ranges for perpetual livestock and game use.

Taking action unprecedented in the history of grazing and public land management, the Forest Service began to restrict the numbers of grazing animals, regulate the grazing period, and set up many other practices to sustain the maximum productivity of the range. A system of land use based on renting allotments by contract to stockmen for summer range use was initiated and enforced by Forest Service officials (*Anon.*, 1926).

Many of the stockowners, however, were excluded from the forest lands due to the necessary limitation of numbers, and these turned their

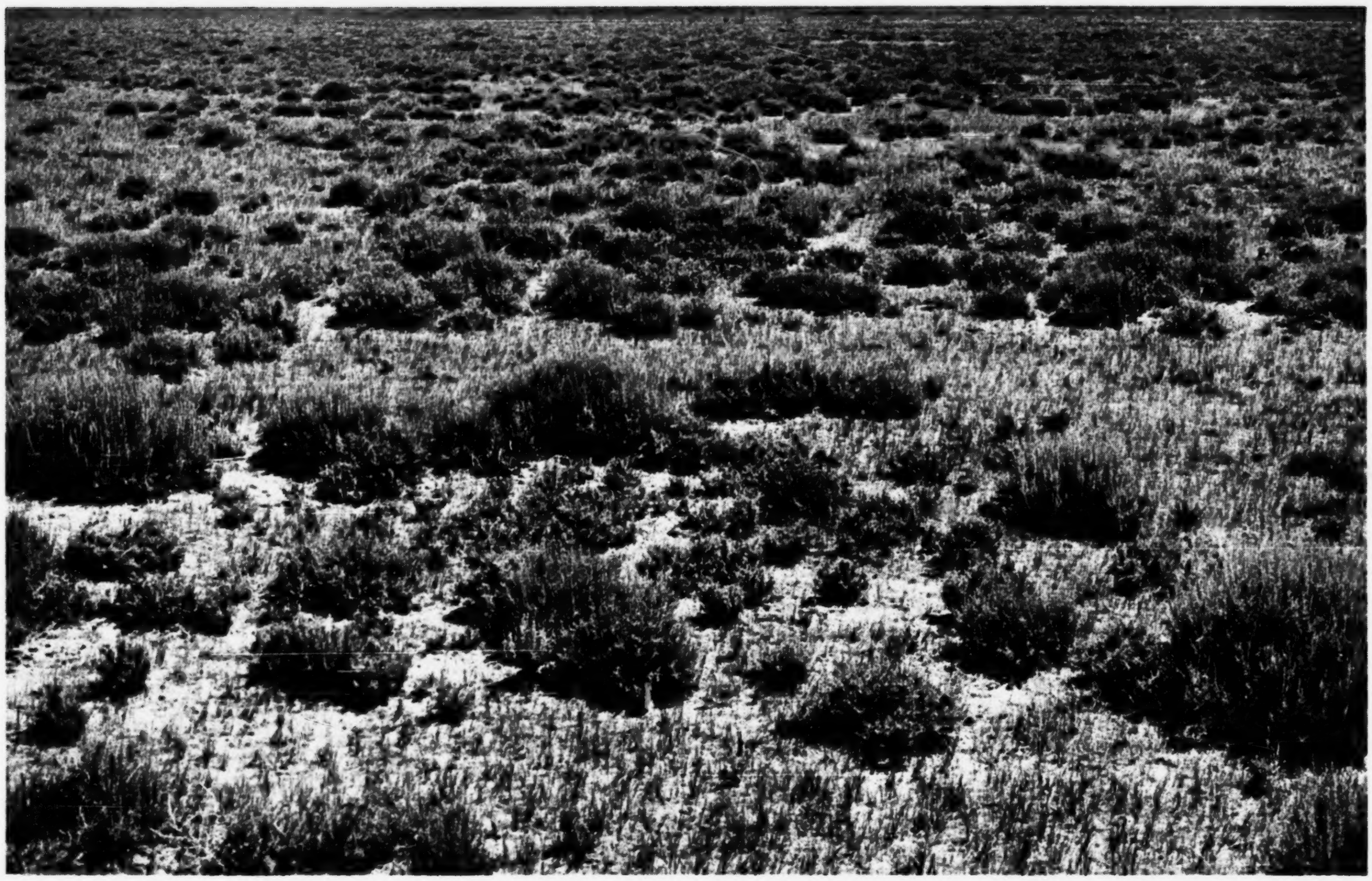

Fig. 23. Big sagebrush-grass community found at lower elevations throughout western Wyoming. Covers nearly 40,000 square miles of the state (Photo courtesy of Dixie R. Smith).

herds to the public domain to graze it in nomadic fashion (*Anon.,* 1926). In 1934 the Taylor Grazing Act was passed and a grazing service later to become the Bureau of Land Management was formed to govern the grazing use of the public domain in order that the proper utilization could be maintained for perpetual use for livestock, wildlife and recreation.

LAND OWNERSHIP IN WYOMING

Of the 62.7 million acres in Wyoming, more than half is owned and managed by the State and Federal governments, most of which lies in the western half of the state. Included in the 29.3 million acres of Federal land, are 16.9 million acres managed by the Bureau of Land Management, 9.1 million acres managed by the Forest Service, and 2.2 million acres in the National Park Service which includes the largest national park, Yellowstone. Other Federal lands comprise 1.9 percent of the 47 percent of federally owned lands in Wyoming (*Anon.,* 1965).

Indian lands comprise 3.3 percent and state and local government lands equal 7 percent of the total. The remainder lies in private holdings which total 42.7 percent of the land in Wyoming (*Anon.,* 1965).

Considering all of the land regardless of ownership, 80.6 percent is rangeland and pasture which includes forest grazing areas. Land used primarily for forest and woodland occupies 10.7 percent and 4.4 percent is cropland (*Anon.,* 1965).

PROPER USE AND MANAGEMENT OF GRASSLANDS

Carrying Capacity of the Grassland

To properly utilize the Wyoming grazing areas, the carrying capacity, or number of animals that the range will carry, should be determined (Beetle, 1960). The four cardinal principles of range management should be applied in each and every situation which involves grazing by livestock or native game animals. First of the principles is *proper numbers* (Beetle, *et al,* 1961), which simply means not putting more animals on an area than that area can support without eliminating or severely damaging a forage species

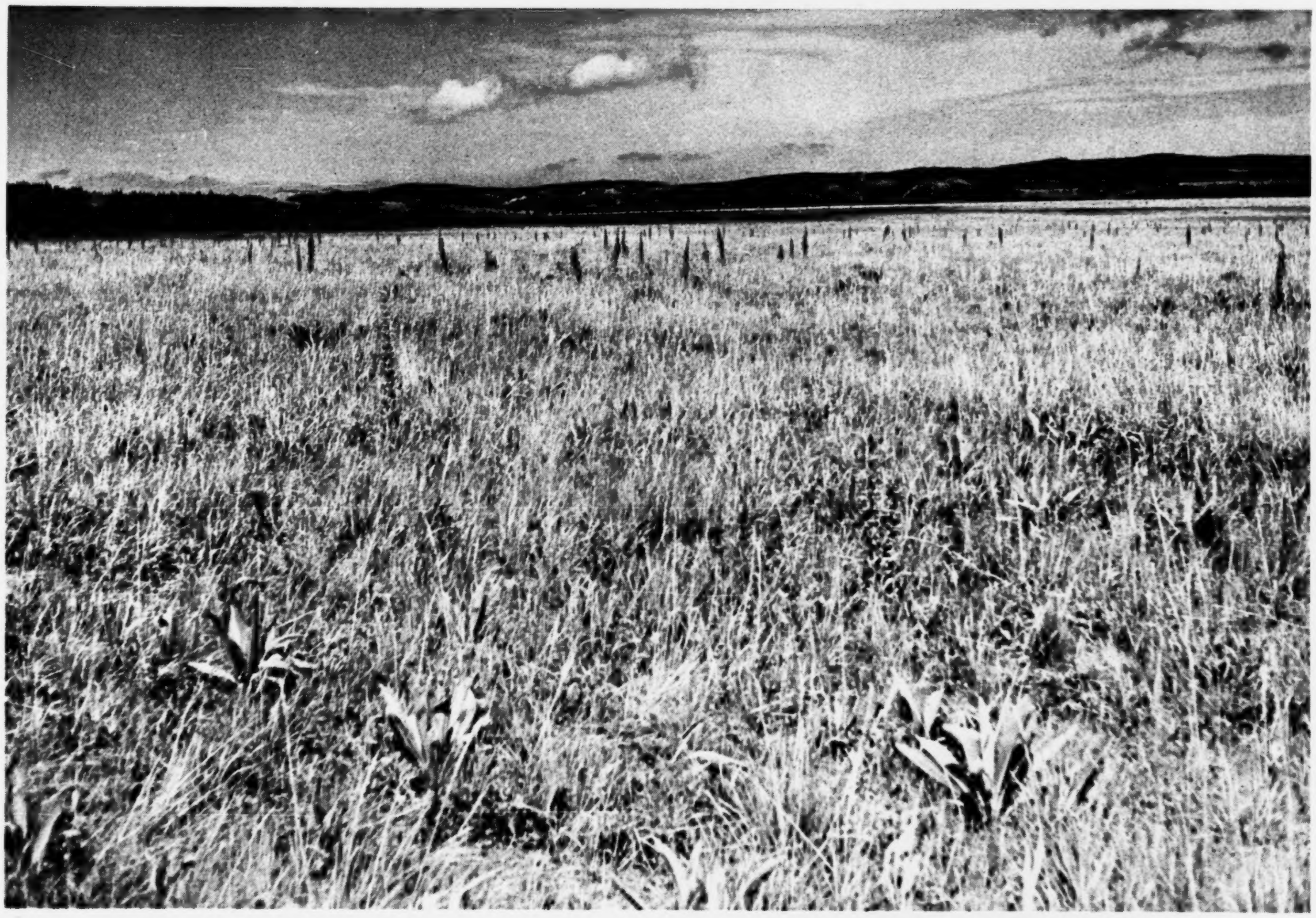

Fig. 24. Summer cattle range of bunch grasses and forbs at 9,000 ft. elevation, Big Horn National Forest (Photo courtesy of Dixie R. Smith).

(Figure 25). *Proper season of use* is the second important factor to be considered when grazing grasslands. The period of initial growth of a grass is the time when the food reserves of the roots are committed to producing the upper vegetative part of the plant. When the green shoot is capable of producing enough energy to support growth, some of the food material can be used to permit root growth and food storage. When livestock or game animals continually graze the young shoots of a plant, the stored food supply of the roots is exhausted and the plant will die (Jardine, *et al,* 1927). The third principle is the importance of *proper distribution* over the range. To function properly each basic principle is dependent upon the other and altering any one will usually affect the other three principles. For instance, sheep tend to "spot-graze" or continually graze the same area to utilize the young green nutritious shoots. If allowed to graze unchecked, sheep will often eliminate the better species in some particular areas of a pasture while the rest of the pasture remains relatively unused. Grazing with different animals, different numbers, or at a different time of year may tend to eliminate spot-grazing. Practices used to correct improper distribution of grazing include fencing (Rauzi, 1963), salt and water placement, deferred-rotation grazing, and in some instances, herding.

Last, and certainly not least of the principles for proper grassland management, is the use of the *proper kind of grazing animals.* Different kinds of animals, such as sheep, cattle, elk, deer and antelope, have natural preferences for different kinds of vegetation (Hyde and Beetle, 1964). For instance, sheep and deer prefer forbs and certain browse species, whereas, cattle and elk will usually select grasses and sedges. When Wyoming's ranges are being used by only one kind of animal, the range is furnishing some plant species that will not be utilized. Thus, when both sheep and cattle or combinations of game and livestock are allowed to graze the same area, the vegetation is more efficiently harvested. Furthermore, this type of grazing it not detrimental to the vegetation unless animal numbers, season of use, or distribution are not controlled. With the development of additional watering facilities much

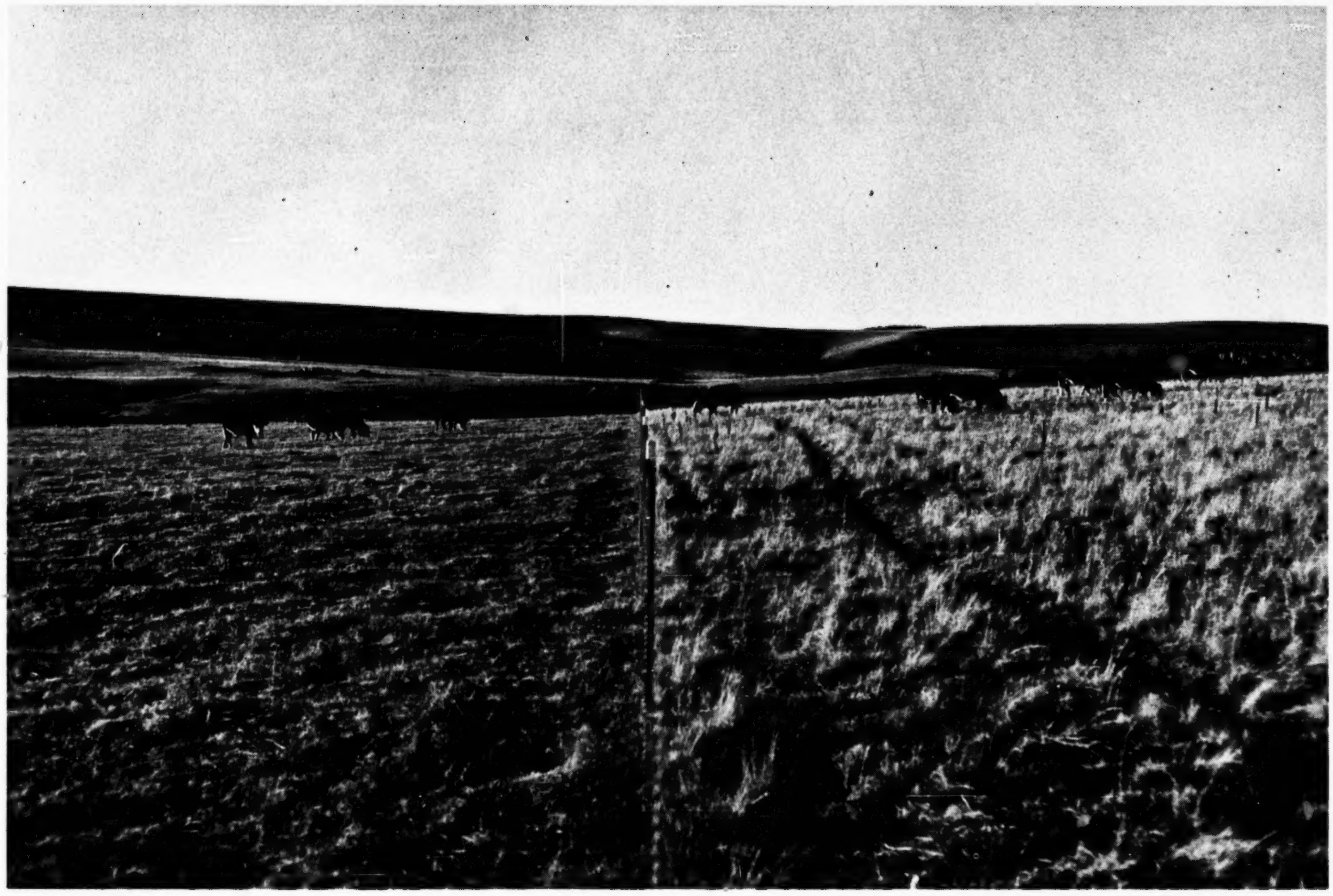

Fig. 25. Grazing intensity trials on the Big Horn National Forest. Medium use on right, heavy use on left.

of Wyoming's rangeland is receiving dual use or grazing by several different kinds of animals.

RANGE IMPROVEMENT PRACTICES

Much of the grazing land in Wyoming has been subjected to abuse which has lowered the carrying capacity and thus the value of the land. As previously mentioned, the time required for an abused grassland to return to its original condition may be quite extensive. Improvement practices applied to Wyoming's rangelands are primarily designed to manipulate the environmental conditions so they are optimum for the production of desirable plants. These practices may be logically evaluated in terms of the four cardinal principles of range management mentioned earlier. Improvements may be made to increase the number of animals the range will carry, or they may be designed to change the vegetative composition making it more desirable for other kinds of animals or making it more desirable for the same kind of animal at other periods of the year. Other improvement practices may result in better animal distribution. Such practices can usually be placed in one of two classifications, mechanical or chemical, each coupled with follow-up management practices.

Mechanical Treatments

Mechanical treatments include pitting (Rauzi, *et al,* 1962), root plowing, chaining, reseeding (Jefferies, *et al,* 1966) and contour furrowing (Rauzi, *et al,* 1962), water spreading (Hubbard and Smoliak, 1953), and numerous other practices such as fencing, stream crossings and stock water developments. In much of Wyoming, where ample water is usually a problem, especially in the summers, methods have been devleoped to take maximum advantage of available moisture. Water spreading devices (Hubbard and Smoliak, 1953) distribute drainage water over larger areas to benefit more plants. Water tanks (Sykes, 1937) have been developed for stock and wildlife in areas where grazing was previously limited because of the water shortage. As a result more land has been made available for grazing use. Such practices as pitting are used to partially disturb the sod, and leave depressions that will catch

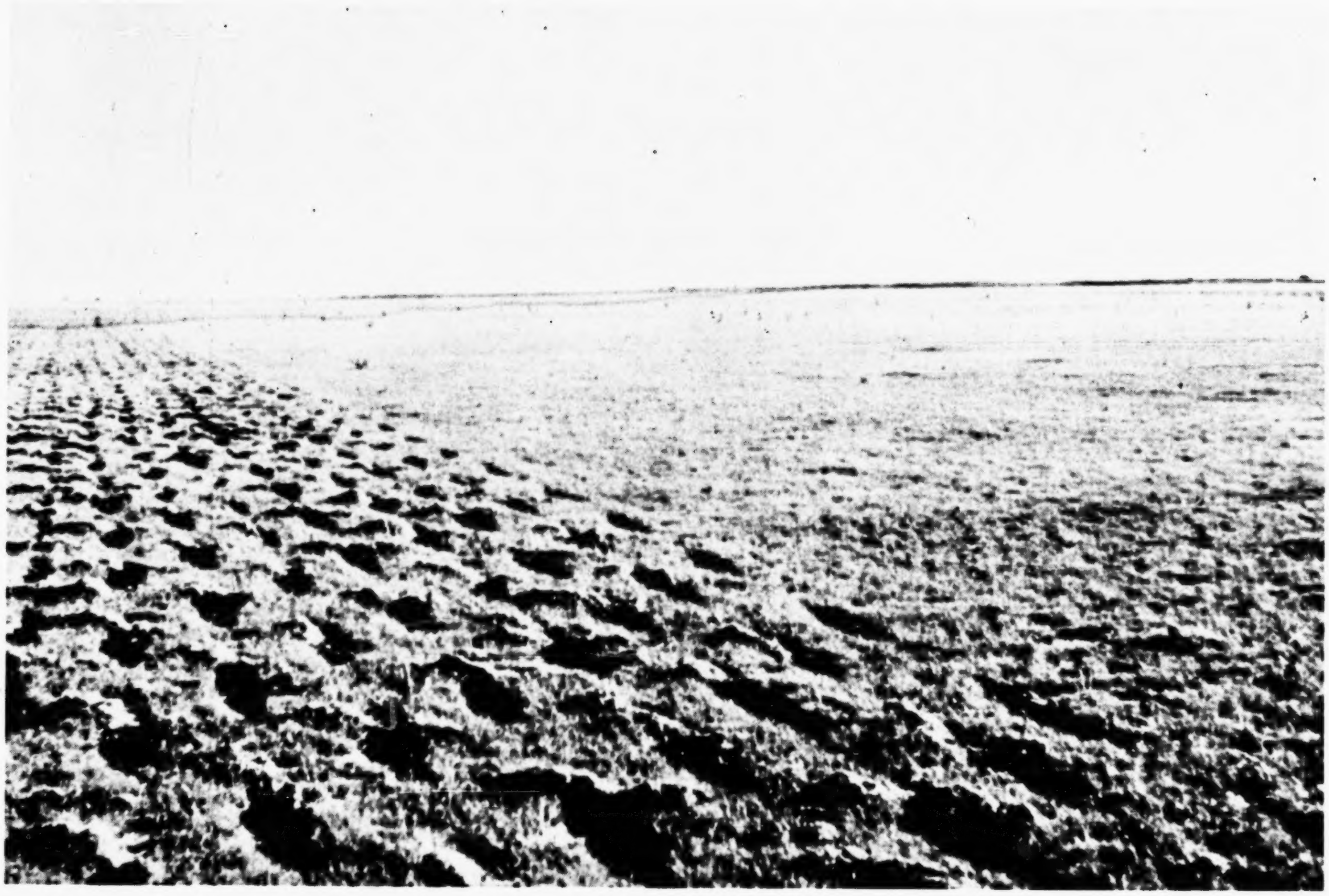

Fig. 26. Range pitting on the shortgrass plains near Cheyenne (Photo courtesy of O. K. Barnes).

and retain precipitation or run-off water for plant growth (Figure 26). Reseeding, in conjunction with most important practices, has proved beneficial. Often the original climax or dominant plants are absent from the present vegetation complex and, therefore, a native seed source is not available. Whenever reseeding, only the species of plants which are best adapted to the site should be used. The best plants to reseed are those which are of excellent grazing value to livestock or native fauna. These would include plants which once occupied the area and those capable of spreading, reproducing, and becoming established on the site (Lang and Landers, 1960). Too often the mistake has been made in which a species not native or adapted to the area has been seeded onto a range. The first year or two may be impressive, but the species soon becomes sparce and eventually disappears from the area because it cannot compete with native species or cannot adapt to the climatic conditions.

The opposite situation can also occur, i.e., where a foreign species will do remarkably well under given situations. The best examples, unfortunately, are often accidental introductions involving plants which are of little forage value or frequently poisonous to livestock. Such introductions include halogeton *(Halogeton glomeratus)*, Russian thistle *(Salsola kali)*, and several other lesser species (Rauchfuss, *et al,* 1957).

When misuse of rangeland weakens the native climax plants, other minor species take advantage of the environmental changes and spread out into the areas once dominated by the better species (Rauchfuss, *et at,* 1957). Such is the case with much land infested with sagebrush (*Artemisia* spp.), prickly pear (*Opuntia* spp.), and undesirable forage plants of little or no grazing value. To control these species the mechanical methods such as root plowing, bull dozing, and chaining are sometimes used.

Selective Chemical Treatments

Application of selective herbicides are being used more each year as a result of their low cost, ease of application and effectiveness (Fisser, 1964). When rangeland is improved by chemical methods, the undesirable vegetation is killed

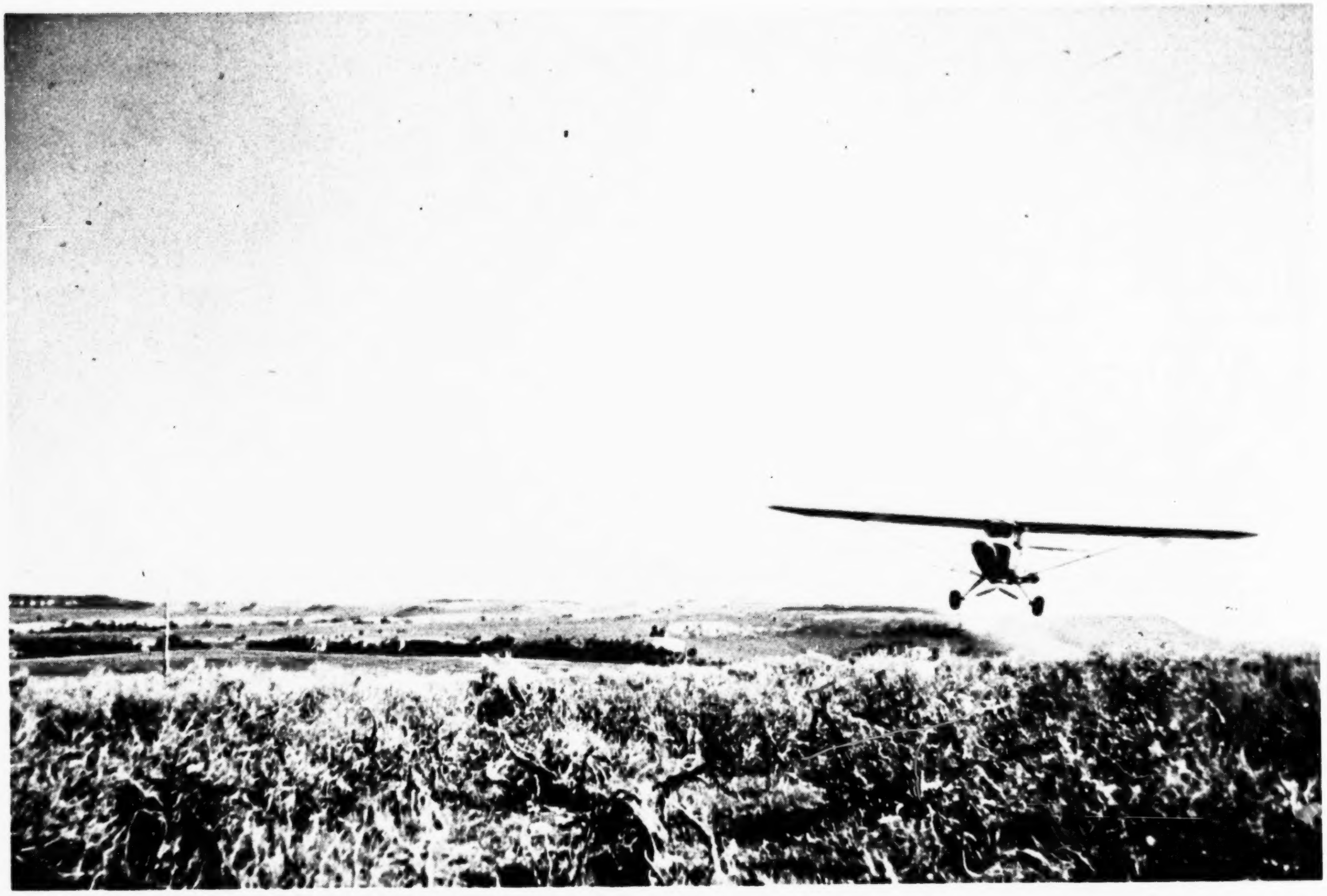

Fig. 27. Spraying big sagebrush with a selective herbicide to increase forage production (Photo courtesy of Harold Alley).

or weakened and the better grasses and other forage producing species are able to utilize the available moisture and nutrients which the weedy plants were using (Alley, 1960) (Figure 27).

Improved range and grassland can support more animals, both domestic and wild, and the benefits usually pay the cost of the operation when good management is practiced following the treatments (Alley, 1965). It should be remembered, however, that when animal preferences for forage or habitat are different, improvement for one kind of animal may not be an improvement for another animal. This is true not only when considering some livestock-wildlife relationships but may be true with different livestock groups that have different requirements or needs.

Applications of commercial fertilizer have increased the amount of plant vigor and nutrition in some instances (Hoglund, *et al,* 1952). This practice has also given increased forage production, increased seed yields, more desirable types of forage, longer grazing season, and increased palatability (Smith and Lang, 1962). Fertilization of rangeland has resulted in obtaining better animal distribution, both of livestock and big game animals.

LAND OF MANY USES—THE MULTIPLE USE CONCEPT

The multiple use concept of land management is being applied in more and more situations of various land ownership and management each year. Multiple use advocates making the best use of available resources of an area for the maximum sustained production or use of those resources (Beetle, 1956). The various aspects include five main categories: timber, range, wildlife, water, and recreation. Each resource is used in a way that will benefit not only the present population, but also the generations to come.

There are, as one would naturally expect, many problems to be met and overcome in managing an area where so many varied interests are concerned. Certainly recreationists do not care for livestock sharing the same campground, and livestock owners do not appreciate people leaving gates open and abusing their property. General disregard for private land has resulted in many potential recreation areas being closed to the public. Such problems as campground selection and maintainance, along with discipline in littering and safety precautions, fall heavily onto the shoulders of public land administrators, but the main responsibility lies with each individual user.

Attempting to produce a healthy forest in conjunction with maintainance of livestock and wildlife results in complications which must be solved by sound management practices. The natural competition between certain species of game animals and livestock must be taken into account (Hyde and Beetle, 1964). In a situation where this consideration is not given, two competing species will first concentrate on the most preferred forage type. Under continued grazing pressure even competition between the same species may occur resulting in the best plants being severely damaged or eliminated from the area (Rush). After the best plants disappear the next preferred plants are taken, until eventually the range cannot support the number of animals, and malnutrition takes its toll (Olsen, 1938).

Unfortunately, overgrazing not only causes animals to suffer, but the range is damaged, and the process of re-establishing the range to its original carrying capacity is a long and tedious process often requiring more years than the average human lifetime (Stoddart and Rasmussen, 1945).

Forest watersheds of Wyoming furnish water used in much of the United States, and if the mountain grasslands are improperly managed, accelerated erosion and silted streams combined with flooding can be devastating to both life and property (Johnson, 1962).

Since the grasslands or rangelands can be managed or manipulated, and since they directly or indirectly affect the other natural renewable resources of Wyoming, they must be properly managed.

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Timber

LOUIS T. BERTLSHOFER[15]

Wyoming, with 9.8 million acres of forest lands (including forested range) comprising 16 percent of the State's land area, is richly endowed with natural renewable forest resources (Choate, 1963). Approximately 50 percent of this area is commercial forest land (Table 3). Commercial forest land is land which is producing, or is physically capable of producing, usable crops of timber, and is available for that purpose. The remaining area of forest land is classed as non-commercial or is reserved for parks and wilderness areas. The potential for the development of Wyoming's timber industry is great. Immediate expansion of the annual harvest of timber is possible. More important, however, a long-term sustained production will benefit Wyoming's economy for many years to come.

Table 3. Area by land classes, Wyoming, 1960 (Choate, 1963)

LAND CLASS	THOUSAND ACRES
Commercial forest land	4,853
Unproductive forest land	2,344
Productive-reserved forest land	2,580
Total forest land	9,777
Non-forest land	52,566
All land*	62,343

*From U. S. Bureau of Census, Land and Water Areas of the U. S., 1960

Wyoming has four principal timbered areas, all lying on well-defined mountain formations. The largest straddles the Continental Divide in the northwestern part of the state. The others are in the Big Horn Mountains, the Bear Lodge Mountains of the Black Hills, and the Laramie and Medicine Bow ranges in the southeastern corner. Scattered elsewhere are islands of forest on isolated ridges and peaks within the Wyoming Basin and the Great Plains (Fig. 28).

The contribution of the timber resource to the local economy in many areas is of major importance and will be much greater as methods of utilization and processing are developed. The industries which harvest and process Wyoming's forest crop rank third in size in the state. One of every eight manufacturing workers in Wyoming is engaged in harvesting timber or processing it in other primary or secondary industries *(Wyoming Forest Industries Committee, 1963)*

FOREST TYPES

The principal wood-producing tree species of Wyoming are lodgepole pine *(Pinus contorta)*, engelmann spruce *(Picea engelmanni)*, ponderosa pine *(Pinus ponderosa)* and douglas-fir *(pseudotsuga menziesii variety glauca)*.[16]

Lodgepole pine is the largest timber type and covers 37 percent of the commercial forest area of the state. Over extensive areas the species has come in following fires and as a result occupies land that could be growing other species. Historically, however, lodgepole pine has provided the majority of the timber cut for all lumber products produced in the state. Since 1910 an estimated 1.3 billion board feet of lumber products have been sawed from lodgepole pine in Wyoming (Choate, 1963). Extensive areas of lodgepole pine suitable for ties were a boon to the Union Pacific Railroad in its construction

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[15] Forest Ranger, Medicine Bow National Forests U. S. Dept. of Agr.

[16] (Trees native to the forests of Colorado and Wyoming, U. S. Forest Service, Rocky Mountain Region, Denver, Colorado).

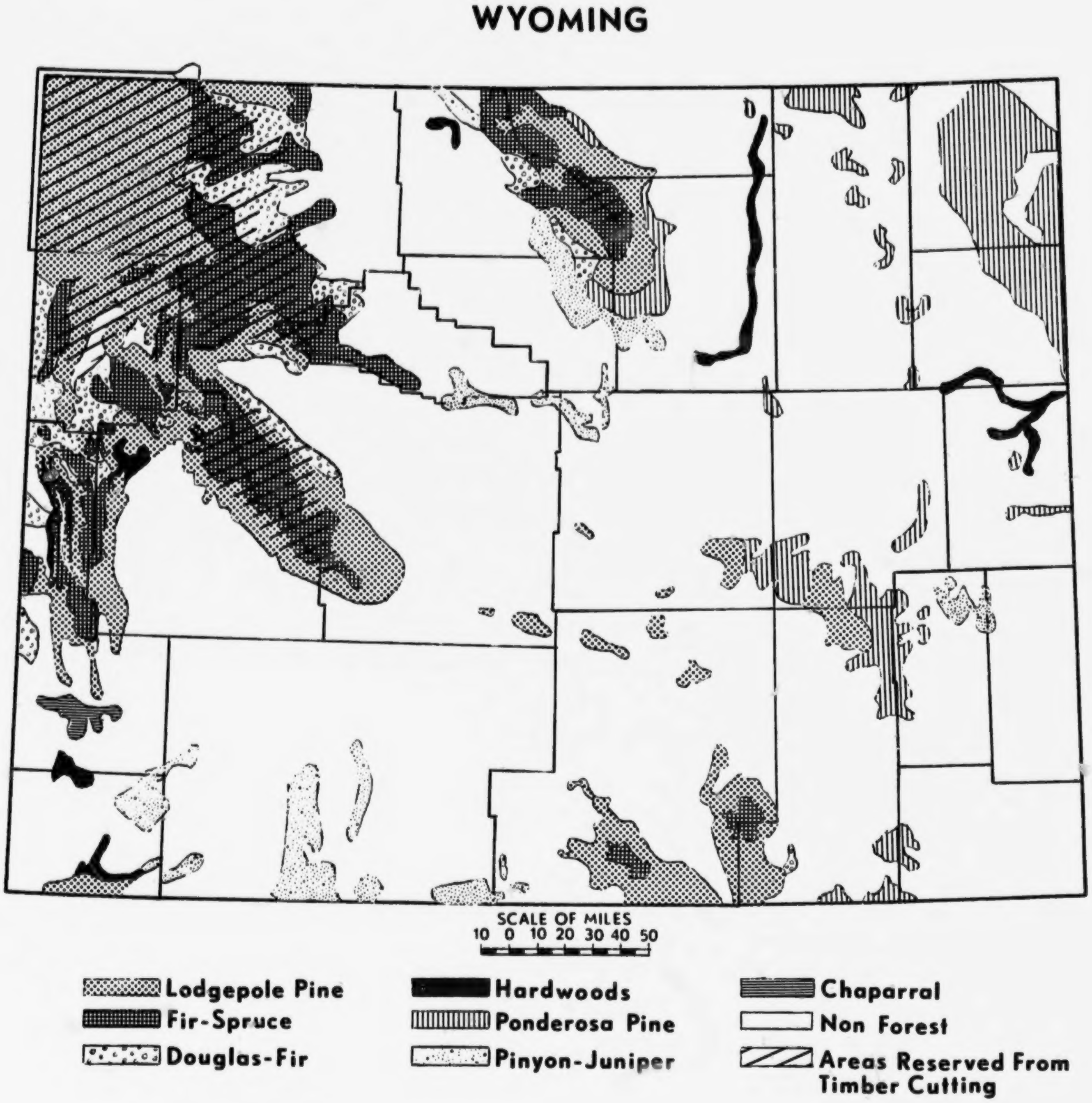
WYOMING
SCALE OF MILES
10 0 10 20 30 40 50
Lodgepole Pine
Fir-Spruce
Douglas-Fir
Hardwoods
Ponderosa Pine
Pinyon-Juniper
Chaparral
Non Forest
Areas Reserved From Timber Cutting

Fig. 28. Wyoming's forest lands and their location.

of the first transcontinental railroad through Wyoming in 1867-69.

Because lodgepole pine is not tolerant of overhead shade and more than half of the lodgepole pine stands are infected with dwarf mistletoe, the most common means of harvesting is by clearcutting, which removes all usable trees in designated patches and strips (Fig. 29). Clearcutting removes all shade from the new trees and the parasite dwarf mistletoe is completely removed so that future spread of the disease can be slowed.

Ponderosa pine occupies 20 percent of the commercial land area of the state. The land upon which it grows is generally low in productivity compared with the other major timber types of the state; however, because of the desirable qualities of the wood, accessibility for logging, and the generally close proximity to transportation systems, ponderosa pine has a long history of heavy and sustained use. Since 1869 about .25 percent of the lumber cut in the state has been ponderosa pine (Choate, 1963). There are no major problems in regenerating the species and therefore this is not a factor which inhibits harvesting.

Ponderosa pine is generally harvested in two cuts. The first cut removes the largest or least acceptable trees and allows a new crop of trees to be established in the understory (that portion of the trees in a forest that is below the main canopy). The second cut removes all the remaining overstory and is applied as soon as the new trees are well established.

The spruce-fir type, which the engelmann spruce is the predominate species, covers 17 percent of the commercial forest land area of the state. More than 80 percent of this timber type is classed as sawtimber; however, the majority of this sawtimber is overmature and is a high risk for epidemic losses from diseases and insects. The spruce-fir type generally occurs at higher elevations and is most commonly found just below timberline. An increased cutting rate in this type is needed to remove the overmature timber, but difficulties in the regeneration of spruce following logging discourages forest managers from greatly increasing the cut.

Clearcutting is the usual means of harvesting engelmann spruce. If the area does not have sufficient reproduction at the time of cutting, young spruce will be planted on the area soon after logging.

Although douglas-fir comprises 14 percent of Wyoming's commercial forests, only about 5 percent of the lumber cut is douglas-fir. Douglas-fir generally grows on steep slopes at lower elevations and is difficult to log. The trees are generally short and limby, which results in many knots, producing a very low quality lumber.

The remaining commercial forest land area of the state is composed of several minor species of pine, aspen and the cottonwoods. The aspen and cottonwoods are generally of a poor quality. Aspen grows mostly at lower elevations and provides scenery and soil stability. Cottonwood grows along the streams and its principal value is for shade, scenery and riverbank protection (Table 4).

Table 4. Area of commercial forest land, by forest types and ownership classes, Wyoming, 1960 (Choate, 1963)

FOREST TYPE	ALL OWNERSHIP	PUBLIC OWNERSHIP	PRIVATE OWNERSHIP
Douglas-fir	701	635	66
Ponderosa pine	992	449	543
Lodgepole pine	1,802	1,700	102
Whitebark and limber pine	166	148	18
Spruce-fir	847	816	31
Aspen	320	236	84
Cottonwood	5	2	3
Other hardwoods	20	8	12
All Types	4,853	3,994	859

CONDITION

The timber stands of Wyoming presently contain many over mature trees. Most sawtimber and many pole size stands are over-mature, over stocked, and are adding little yearly net growth. This occurs mainly in the lodgepole pine areas. Where heavy competition results in small trees throughout the life of the stand, the task of thinning this timber is one of the larger forest management problems facing Wyoming foresters and land owners (Fig. 30). Although individual trees continue to grow in these stands, gains in new wood are offset by losses through death by insects, disease and fire. These high losses can be reduced by an increased cutting of old growth forests. Although some thinning is possible on a commercial basis for posts and poles, in most areas commercial thinnings will not be possible until there is a greater pulpwood market.

OWNERSHIP

The public owns 82 percent of Wyoming's 49 million acres of commercial forest land. Sixty-nine percent of the public land is administered by the United States Forest Service and the remaining public lands are administered by other Federal agencies such as the Bureau of Land Management and the Bureau of Indian Affairs. The State manages the 111,000 acres of commercial forest land it owns. Private interests own 859,000 acres, or 18 percent, of the commercial forests of the state. (Table 5).

Table 5. Area of commercial forest land by ownership classes, Wyoming 1960 (Choate, 1963)

OWNERSHIP CLASS	THOUSAND ACRES
National Forest	3,364
Other Federal	
Bureau of Land Management	395
Indian	124
Total Federal	3,883
State	111
Farmer Owned	622
Miscellaneous Private	237
All Ownership	4,853

FOREST PRODUCTS

Lumber leads the long list of Wyoming's forest products (Table 6). Wyoming lumber is used in the building industry for both construction and finishing materials and is shipped to markets throughout the country. (Fig. 31). Much of this construction material is in the form of 2x4 studding that is cut to construction lengths for home and industrial building. There are several

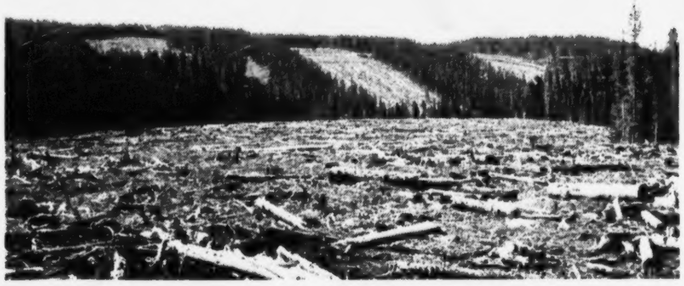

Fig. 29. A recently logged area on the Medicine Bow National Forest. Clear cutting patterns are seen in the background. Clear cutting removes all usable trees in the strips, eliminates shading of new trees, and dwarf mistletoe is eliminated as a danger to new growth.

Table 6. Annual cut from live sawtimber on commercial forest lands by products and logging residues, Wyoming, 1962 (Choate, 1963).

PRODUCTS AND RESIDUES	ALL SPECIES THOUSAND BOARD FEET*
Roundwood products	
Sawlogs	114,193
Pulpwood	1,739
Mine timbers	33
Misc. industrial wood	199
Posts	143
Fuelwood	4
All products	116,311
Logging residues	7,745
Total Timber Cut	124,056

*International ¼ rule

mills in the state that produce only this type of lumber (Fig. 32).

Railroad ties have also been an important product since the first railroads crossed Wyoming. About .5 million ties are manufactured in Wyoming each year, primarily from lodgepole pine. All of the ties used by the Union Pacific Railroad are treated at the Laramie Tie Plant. The mining industry uses shoring timbers and farmers and ranchers cut poles and posts for fences and logs for buildings and animal shelters.

Increased utilization of what was previously wasted material has been on the increase in recent years. Some plant residues in the form of slabs, edgings and trimmings are presently being chipped and shipped to pulpmills in the Lake States. Continued shipment of pulpwood to out-of-state mills is expected for some time, since no pulpwood mill presently exists in the state. In 1962 about 17,000 cords were shipped to the Lake States (Choate, 1963). This outlet, however, can never offset the advantages of a pulp and paper development with Wyoming.

Construction of fiber industries, such as pulpmills or fiberboard plants, in the state would provide additional outlets for such sawmill residues and chippable logging slash. Debarking equipment, however, would have to be installed in many sawmills of the state. Debarking provides for the recovery of milling wastes and benefits sawmill operations by reducing equipment maintenance and improving lumber recovery.

Some studies have recently been made concerning the potential for a pulpmill in the State. The forest lands would benefit substantially from such a market for wood fiber. The management of most of the timber types of the state calls for clearcutting. Previous markets for wood products have left small or defective trees, tops and limbs, remaining on the area. Everyone would benefit if most of this material could be removed as a part of the logging operation.

OTHER USES OF WYOMING'S FOREST LANDS

Timber production provides only one of the values of Wyoming's forests. Camping areas for the recreationists, fishing and hunting for the sportsman, and grazing for domestic stock, as well as wildlife, and water are other uses.

Water

The importance of Wyoming's forests for the production of water has long been recognized. Like many of the western states, the present and future development of Wyoming is dependent on water. This could support the claim of many that water is the most important product of Wyoming's forests.

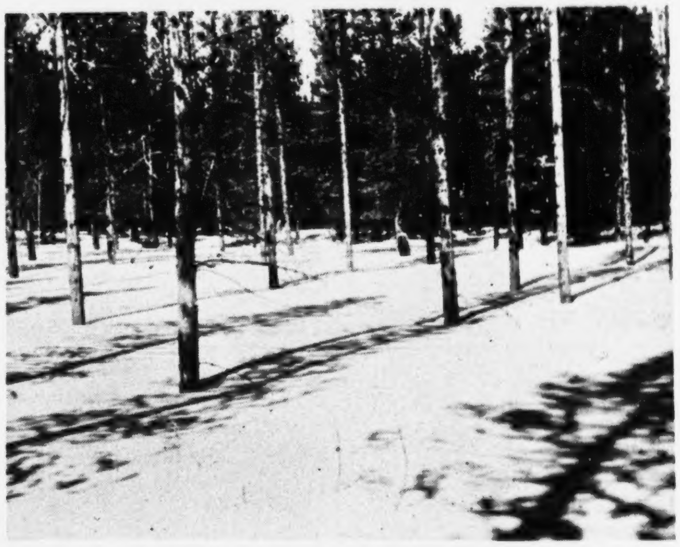

Fig. 30. Recently thinned stand of lodgepole pine on the Medicine Bow National Forest. Thinning increases the growing space of the remaining trees and can greatly increase sawtimber yields on better sites.

Forest lands produce about 54 percent of the runoff, although they comprise only 16 percent of the total land area of the state. Precipitation is soaked up by the forest vegetation as it falls as rain or snow and is then released slowly for greater downstream use.

Studies are being conducted to determine the effects of various plants, soil types and land uses upon the yield of water. The main objective of most of these studies is to increase the yield and improve the quality of the water, while preventing floods and soil erosion.

The harvest of timber increases the water yield of the forest. Investigations have found that increases in streamflow followed the removal of half of the timber from the watershed of a snow-fed stream (Goodsell, 1958). Removal of this timber with good logging techniques permits the snow to reach the forest floor, reducing the amount of moisture lost by evaporation. Research conducted at the Fraser Experimental Forest in Colorado shows that only half of the annual precipitation on the forest becomes streamflow (Love, 1959). Well managed forests can thus be expected to continue to furnish water of the necessary quantity and quality to meet Wyoming's needs now and in the years to come.

Wildlife

The forested areas of Wyoming provide the wildlife habitat that maintains the majority of the big game species of the State. In addition, the forest is home to small game such as rabbits, grouse, partridge and the fur bearing animals. All of the State's sport fishing depends upon the high forested watershed which maintains a year-round flow of water in the mountain streams. Properly managed forests make the best wildlife habitat and provide good clean water to maintain fishing streams, lakes and reservoirs.

Big game is one of Wyoming's major attractions. Deer, elk, moose, bear, bighorn sheep and other big game species provide annual sport for many hunters. Maintaining the summer and winter ranges used by these big game and coordinating their use with other uses of the forest lands are important management problems. For example, grazing areas for domestic livestock must be coordinated with the winter forage requirements of wildlife, and timber management must consider the effects that cutting will have on the summer range of wildlife.

Natural openings in the timber are important to our big game populations. Wildlife habitat research studies have concluded that conservative, selective logging improves big game habitat. Reynolds (1964) found that small, natural openings should be maintained and that openings created by timber cutting contribute to the best over-all land use. Reynolds (1964) also found that deer use forest borders heavily in the spruce-fir areas and elk use openings to the greatest extent in ponderosa pine areas. Forage production increases with logging and the thinning of pole-sized stands of timber results in an increase of available forage for wildlife.

Recreation

No other use of the forests of Wyoming has increased at the rate that recreation has since World War II. In addition to some of the most magnificent scenery in the nation, opportunities for camping, hiking, riding, boating, hunting and fishing have all contributed to recreation's surging development in recent years. Because of the expanding national population and Wyoming's location, our forests are rapidly assuming their share of the recreation boom. There are indications of even greater increases in the recreation use of these forests in the future. Wyoming's forests have, in effect, become the backyard of Americans from coast to coast.

Use is not restricted to only the summer months. Winter sports are rapidly on the increase. Skiing has been on the increase for some time, but the recent popularity of the "over-the-snow" machines has opened previously remote areas of the forest to winter use. Summer homes, fishing spots, etc., previously unused during the winter months, are now open for year-round use by these machines.

The special quality of outdoor recreation in forested areas is in the wide variety of activities available. The camp site is often only a base of operations. Hiking, fishing, photography, nature study, and sightseeing may be among the activities the camper may decide to participate in. All are available for his choosing.

With this increased competition on our forest areas, management decisions need to be made in response to new situations and problems. This is especially true on public lands. Timber management must consider the scenic values of present and proposed recreation sites when timber harvesting operations are considered.

Recreation is not new to Wyoming. Yellowstone National Park was established in 1872 as the first major area in the country set aside for the preservation of the natural resources. Since that time other areas such as the Grand Tetons have been established.

Remoteness which delayed development in much of the State now is an important attraction. Wyoming has a number of Wilderness and Wild

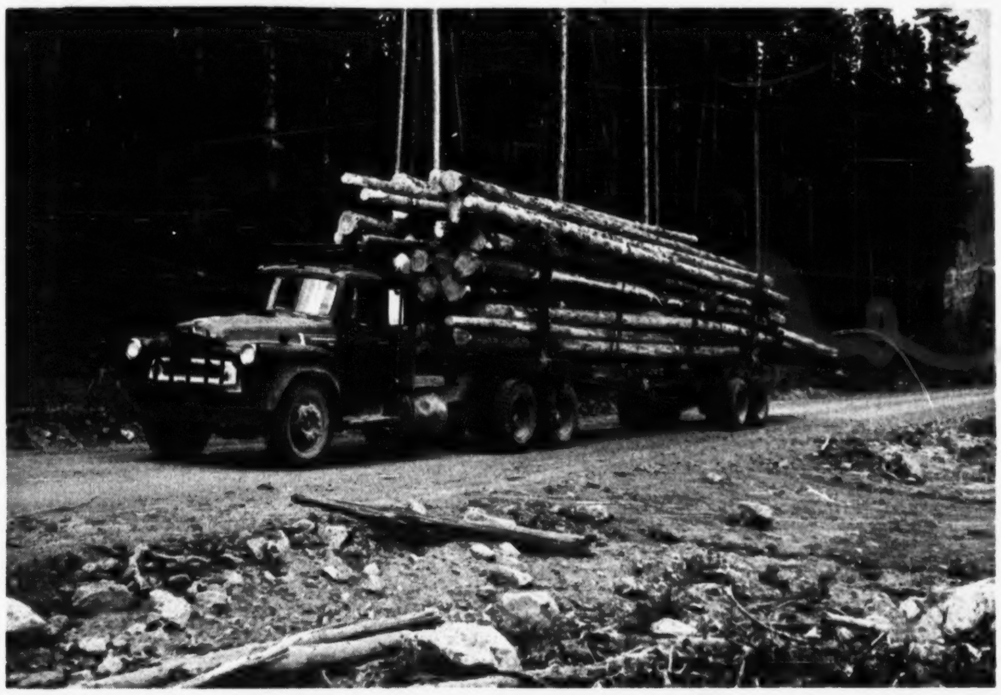

Fig. 31. Sawlogs from Wyoming forest land heading for the sawmill in a nearby town.

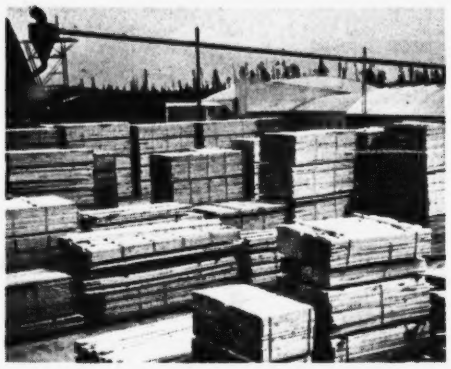

Fig. 32. Lumber stacked in a sawmill yard awaiting shipment throughout the state and nation.

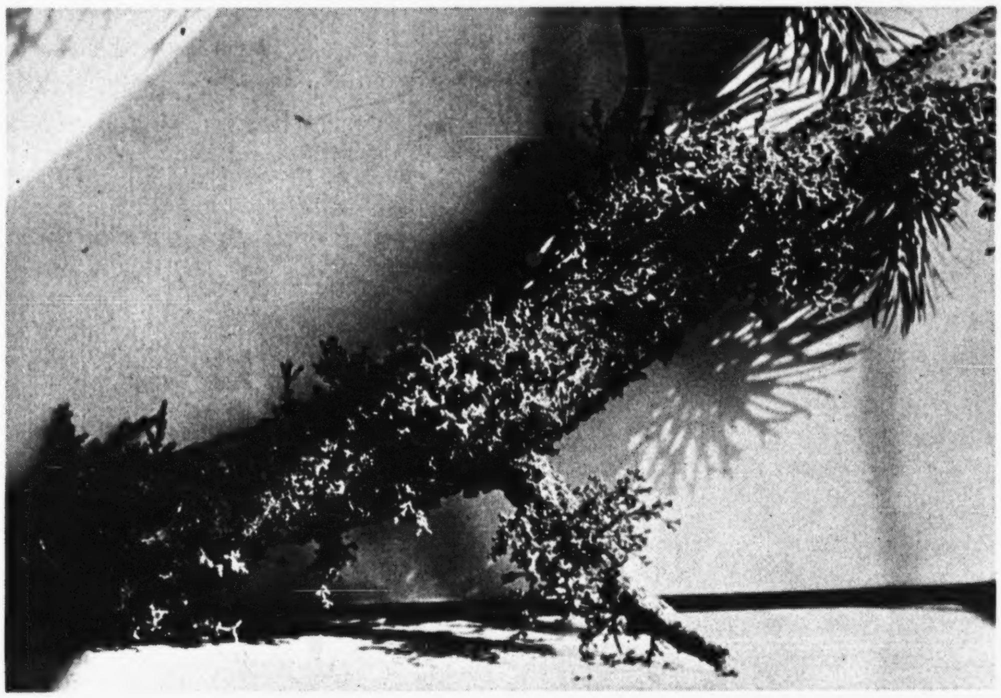

Fig. 33. A dwarf mistletoe infected limb from a lodgepole pine. Clear cutting followed by slash burning is generally the only feasible means of eliminating this parasite in heavily infested stands.

areas reserved and protected by the Secretary of Agriculture under the Wilderness Act of September 3, 1964 (Public Law 88-577). Commercial timber cutting, roads, motor travel, or any permanent developments are prohibited in those areas, except for essential administrative facilities such as fire lookouts.

National Parks, National Monuments, Wilderness and Wild Areas, and State Parks remove large areas of Wyoming from possible timber activity. 2.6 million acres of productive forest land are reserved in areas such as these. In addition to providing recreation for millions of Americans, these areas provide homes for wildlife and valuable watersheds for the state. However, with proper management of the presently available commercial timbered lands, a sustained yield of timber products can be produced to meet present and future demands.

Grazing

Sheep and cattle have grazed Wyoming's slopes for decades. Some 9 percent of the cattle and 15 percent of the sheep spend at least part of each year grazing on the National Forests. Private landowners use grazing as an integrated part of their management of forested lands. It is often their primary source of income. Carefully planned timber harvests often improve forage production and increase the income from the land by both grazing and timber harvest.

Most livestock grazing is on alpine meadows and grasslands found intermingled with the forest lands. While cattle prefer the natural openings, some use is made of the logged areas. Improved management practices such as rotation grazing and deferred grazing are now being used in some sections to improve range conditions and increase forage and livestock production.

FOREST PROTECTION

Fire is best known to the public as the destroyer of forests. Over the years thousands of acres have been destroyed and many lives lost. In addition to damaging the timber crop, forest fires endanger other forest values vital to Wyoming, such as watersheds, fish, wildlife, grazing and recreation facilities.

The job of protecting these forested areas belongs to everyone who uses them. The State Forestry Division provides assistance in organizing fire suppression forces on state and private lands.

Keep Wyoming Green is a volunteer organizations of individuals, state and private organizations. It was formed to educate the public about the dangers and costs of forest fires and to ultimately help prevent fires.

Although far less dramatic than fire, insects, disease and other enemies of the forest are far more destructive to Wyoming timber. Two-thirds of the annual mortality is caused by disease and insects. The toll by mortality and growth loss caused by insects and disease is more than 50 percent greater than the harvest by all the wood-using industries in the state.

Dwarf mistletoe *(Arceuthobium americanum)* is the principal cause of low productivity in lodgepole pine (Fig. 33). A parasitic seed plant, it deforms trees, reduces their growth and quality, and kills many of them. The extent of this condition is not known, but undoubtedly it covers thousands of acres through the state. The spread of this parasite is slow; therefore, effective reduction can be accomplished by clearcutting in large, compact patches. Follow-up is necessary to kill all infected unmerchantable trees left on the clearcut areas (Hawksworth, 1963). Since 45 percent of the sound, live trees in Wyoming's commercial forests are lodgepole pine, their losses are particularly great.

Mistletoe is very prevalent in areas logged for railroad ties during the years the railroads laid their tracks west. Trees that were unsuitable for ties were not logged. Partially stocked stands were left, in which the mistletoe already there could thrive. These lands cannot become fully productive for timber until new stands are started.

Insects such as the Black Hills beetle *(Dendroctonus ponderosae)*, the mountain pine beetle *(Dendroctonus monticolae)*, and the englemann spruce bark beetle *(Dendroctonus engelmanni)* are among the forests' most dangerous enemies. Constant vigilance and prompt action are needed to avoid serious outbreaks. In most cases the insects attack the large, overmature trees and then move to others. The overmature engelmann spruce stands are highly vulnerable to outbreaks of the engelmann spruce beetle. Control of this beetle is especially critical because the infested timber is often inaccessible and spruce is difficult to regenerate. The Black Hills beetle is a constant threat to ponderosa pine stands and the mountain pine beetle attacks the immature and mature lodgepole stands.

Natural enemies and extremes of weather often help to control insect outbreaks. Foresters attempt to control insect outbreaks by cutting the infested areas and using the logs for lumber or by spraying the bark or needles with appropriate chemicals to kill the insects.

Much of Wyoming's forest land is covered with stands of overmature trees whose vitality has declined with age. Other stands are weakened by overcrowding. These timber stands are most susceptible to insect and disease attack. An increase in the annual cut is needed to remove the more susceptible overmature timber from the state. It will probably be many more years before this can be accomplished.

However, the future of Wyoming's forest resource is bright. The forest, like the other resources in the state, will feel the pressures of an expanded population.

The capacity of the forest to provide sufficient water, recreation and grazing will be taxed. The demand for timber will also increase, but present demands are far below potential production. If the timber potential is to be utilized, new products, methods and markets will have to be developed. With their development will come new jobs, larger payrolls and more intensive interest in the practice of forestry.

In the future very few acres of Wyoming's forest lands will be managed for timber only. Water, recreation, grazing, wildlife and timber are all products of the natural resource we call our forests. Continued good management of the forest resource will benefit Wyoming for generations to come.

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Game and Fish

KENNETH L. DIEM[17] and THOMAS BELL[18]

Wyoming's land surfaces of grassy plains, high deserts, sagebrush covered foothills, coniferous forests, bare rock peaks, ponds, lakes, and streams support a wide variety of wild animals. Current estimates list 344 species of birds, 107 species of mammals, 73 species of fish and 38 species of reptiles and amphibians.

Most of the early explorers confined their observations to those wild animals which were important as sources of their food as well as to those wild animals which were potential threats to their party's safety. The earliest recorded observations of wild animals in Wyoming were made by Larocque in 1805 (Hazlitt, 1934).

As settlers moved into the Wyoming Territory, commercial exploitations of many of the wild animals were inevitable. The historic slaughter of the bison is well known, but many other animals were either slaughtered for their hides or driven from their native plains areas to secluded mountain regions. In 1875, Governor Thayer reported that more than 3,000 elk hides had been shipped from the Union Pacific Railroad Stations between Laramie and Green River in a six month period. As a result, the 1875 Territorial Legislature prohibited hunting of big game except for food (Larson, 1965).

This law did not curb many hunters from taking more meat than they could use or curb the selling of hides. Holiday hunting parties in Uinta county were described returning home with wagons piled high with grouse and sage hens (Stone, 1924). In 1875, on Deer Creek, near Fort Fetterman, John Hunton described an elk hunt with a friend when they killed 97 elk in one day (Flannery, 1956-64). Even the native trout were heavily used on occasions. During the summer of 1876, Crook's army reportedly caught 15,000 cutthroat trout near his Big Goose Creek camp, which is now the townsite of Sheridan (Larson, 1965). Continued selling of thousands of big game hides in northern Wyoming, prompted the 1886 Legislature to prohibit shipping of green game hides from Wyoming and to make it illegal to kill more than two big game animals per day. The killing of bull elk for their canine teeth (tusks), which were sold as Elks Lodge emblems, resulted in the 1907 Legislature enacting the only felonious state statute in the United States related to game animals. It made the wasteful killing of any big game animal solely for its tusks, antlers or head a felony (Larson, 1965).

Artificial propagation and stocking of fish species in Wyoming began in 1880, with the planting of eastern brook trout and carp species. The winter feeding of elk in Jackson Hole and the Upper Green River Valley in the hard winter of 1909-10 marked the beginning of artificially maintained elk feed grounds (Larson, 1965). Initiation of artificial propagation and stocking of game birds began in Wyoming in .... with the creation of the Game Bird Farm at Sheridan.

Today, the wild animals of Wyoming are important attractions for the tourist's and outdoor recreationist's photography, sight-seeing, fishing and hunting interests. As objects of sport fishing and hunting, 23 species of game fish, 36 species of game birds and small game, and 8 species of big game were estimated to have contributed a minimum of 60 million dollars directly attributable to hunting and fishing activities in 1965. Using information from the Wyoming Bureau of Business Research, the secondary effects of this spending amounts to 39 million dollars. The total effect of hunting and fishing on Wyoming's economy is equal to 99 million dollars or the same as having 10,000 people earning an annual salary of $9,900 (Walther and Birch, 1966).

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BIG GAME

Pronghorns

PRONGHORN (Antelope), *Antilocapra americana*. The pronghorn antelope is not a true antelope. It is found only on arid North American open prairies, deserts and sagebrush plains. Pronghorns are present in every county of Wyoming and may occur at elevations over 9,000 feet, as they do in the southeast section of the Absaroka range. Both the male and female carry true horns which consist of a bony core covered by a horny sheath. The branching and annual shedding of this horny sheath is unique to the pronghorn (Fig. 34). The single branched sheath of the male is most noticeable with the greatest recorded horn length being 20¼ inches. They have keen eyesight and are considered to be the swiftest runner of any North American mammal. Pronghorns are both browsers and grazers, feeding on sagebrush, rabbit brush, greasewood, saltbush, forbs and grasses. In some areas of Wyoming the pronghorn will migrate between winter and summer ranges. In 1965, an estimated 26,172 antelope hunters spent 3.5 million dollars harvesting an estimated 23,944 pronghorns in Wyoming (King, 1966; Walther and Birch, 1966).

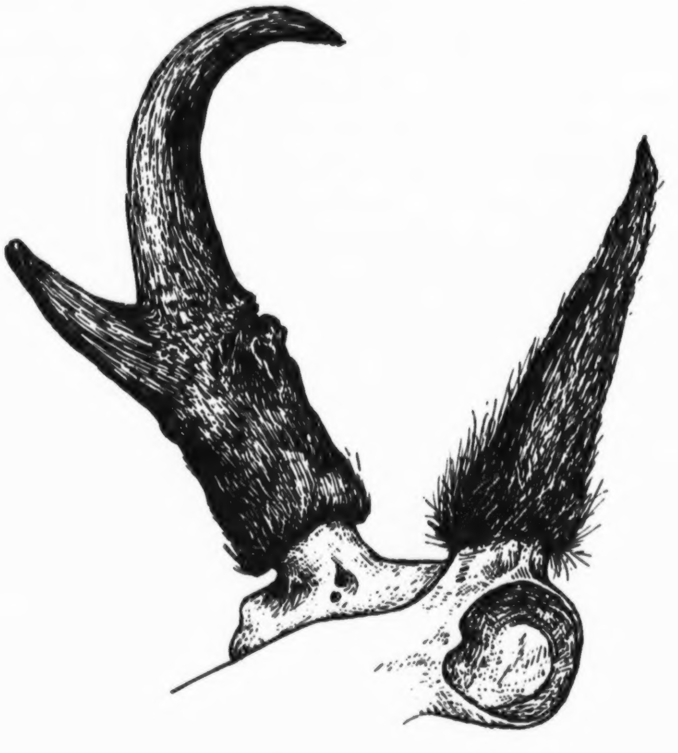


Fig. 34. Pronghorn skull with branched right horn sheath attached and left horn sheath removed showing bone core with new horn sheath development (Illus. by M. Lester).

Wyoming has more antelope than any other state. In 1908, they were thought to be headed toward extinction when their numbers dropped to an estimated 20,000. Indiscriminate and improperly managed hunting, fencing, destruction of sagebrush and overgrazing by both wild animals and domestic stock are detrimental and may have caused such a decline. Through management, their numbers increased from the low 1908 levels to an estimated 165,000 animals in 1960. Since 1960, their numbers have again begun to decline. Once again, it must be determined how serious this decline may be and what corrective measures will assure preservation of this unique Wyoming heritage.

Deer

The deer include our deer, elk and moose. All members of the deer family are hoofed mammals having antlers which are shed annually; they all chew their cud.

WHITETAIL DEER, *Odocoileus virginianus*. Whitetail deer are probably the best known big game animal of North America. Their distribution in Wyoming is spotty. The largest herd is located in the Black Hills region where coniferous forests are mixed with deciduous or hardwood trees and croplands. Other scattered, smaller populations are found along rivers and streams having cottonwood bottomlands closely associated with croplands as generally found in the eastern half of Wyoming, particularly around Sheridan, Kaycee and Glendo. Adult males have antlers consisting of a main beam with unbranched tines (Fig. 35). When startled, the whitetail lifts its bushy tail and flashes the white underside as if it were a signal flag. Whitetails are browsers, feeding on twigs of woody plants, mushrooms, and acorns. At various times of the year they may also feed on grass, forbs and farm crops. Despite being very secretive, these deer have become remarkably tolerant of man and his activities. They normally are only slightly migratory. An estimated 14,000 hunters were believed to have harvested 10,000 whitetails during the 1965 hunting season in Wyoming (King, 1966).

MULE DEER, *Odocoileus hemionus*. This animal of the West occupies a variety of habitat

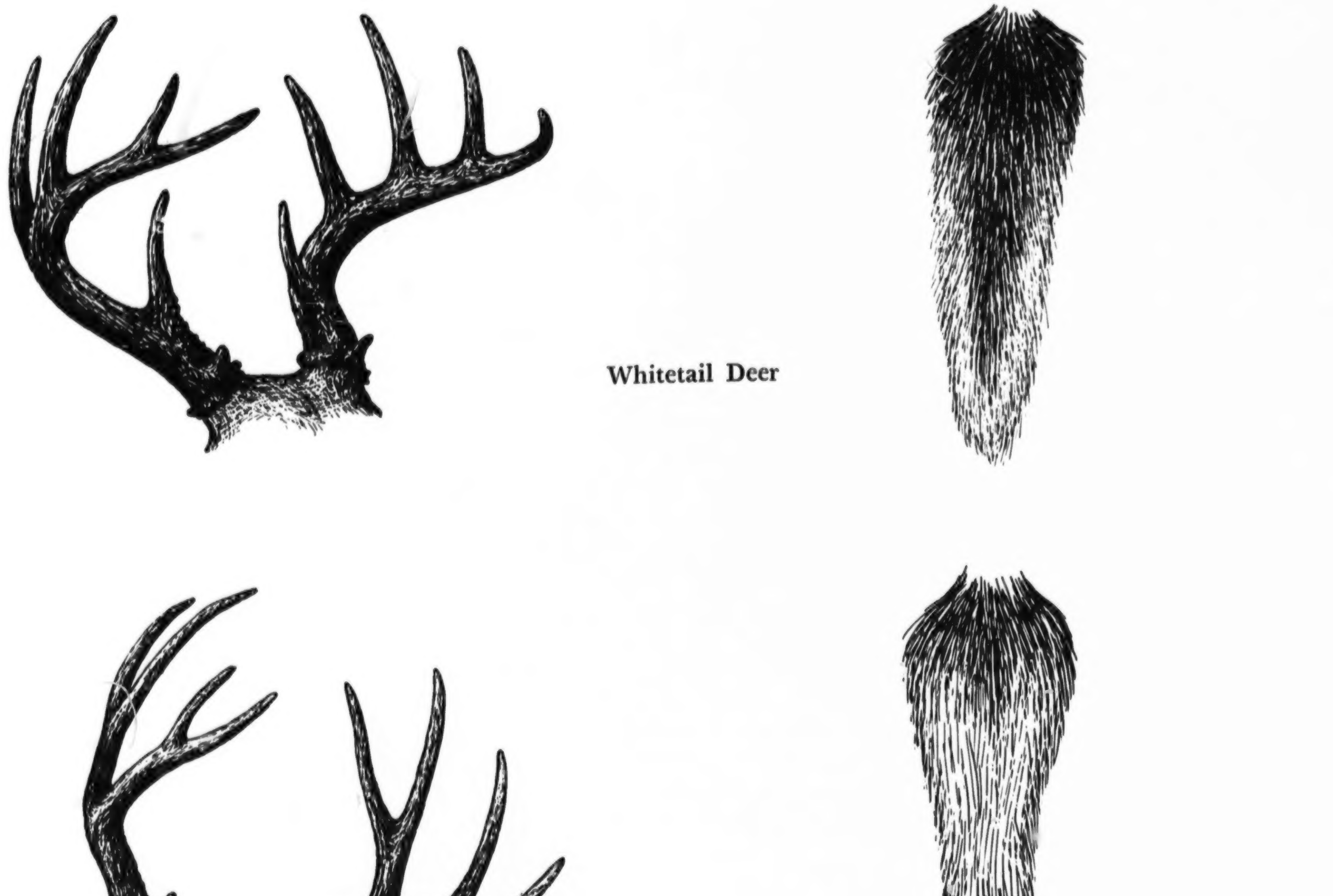

Whitetail Deer
Mule Deer
Elk
Moose

Fig. 35. Typical antlers of Wyoming's deer family, plus characteristic tail differences between mule deer and whitetail deer (Illus. by M. Lester).

from coniferous forests and alpine meadows of the mountains to the shrubby grasslands of the desert regions. Its distribution is rather general, though not equal, in every Wyoming county. Only the buck has antlers whose tines are branched after leaving the main antler beam (Fig. 34). In addition, a small white tail tipped with black and large mule-like ears characterize this species. Mule deer are mainly browsers feeding on mushrooms and twigs of woody plants. However, they do graze on considerably more forbs and grasses than whitetails do. They are less secretive and are relatively less tolerant of man and his activities than is the whitetail. Migratory movements are common to escape deep winter snows of the mountains. Approximately 75,000 hunters harvested about 52,000 mule deer during the 1965 Wyoming hunting season (King, 1966). Total direct expenditures by whitetail and mule deer hunters in 1965 amounted to 11.3 million dollars (Walther and Birch, 1966).

ELK (Wapiti), *Cervus canadensis.* Once elk roamed over most of the United States. Now they are confined to the semi-open coniferous forests and meadows of mountains and plateaus, foothills, and some plains of the adjacent countryside. They are found in every Wyoming county except Campbell, Niobrara, and Goshen counties. The largest and most famous elk herds are found in Jackson Hole. The National Elk refuge, administered by the U.S. Bureau of Sport Fisheries and Wildlife, is home for 8,000 to 12,000 elk every winter. Wyoming's most productive elk herd is the Tongue-Goose herd on the northeast ranges of the Big Horn Mountains. The most unusual elk herd lives amongst the Red Desert sagebrush and sandhills near the Boar's Tusk, north of Rock Springs. All adult bulls have large branching antlers with beam lengths which may reach 64 inches. Elk have a characteristic heavy brown mane and a pale yellowish rump patch. Elk are generally considered to be grazers, feeding on forbs and grasses. Under winter conditions they will browse on twigs and bark of woody plants. They are not very tolerant of man's activities and require large tracts of relatively wild country to survive. Seasonal migrations from low to high elevations are common. In the 1965 elk season an estimated 30,613 hunters spent 9 million dollars harvesting an estimated 12,054 elk (King, 1966; Walther and Birch, 1966).

MOOSE, *Alces alces.* This largest member of the deer family is found in the northern coniferous forests having abundant lakes and wetland or swamp areas with willows and other woody plants. Moose are generally present in the counties of the western half of Wyoming. At times, they may even be observed wandering aimlessly across desert areas of these counties. Some of the largest moose populations in Wyoming are found in the Gros Ventre River and the Upper Green River drainages. Moose are characterized by a grotesque size, heavy palmately flattened antlers on adult bulls, an overhanging or pendulous muzzle and the hanging throat "bell". They are browsers, feeding upon twigs and occasionally bark of woody plants. In the summer, they will feed on submerged aquatic plants. Seasonal migrations to escape the deep snow of the high mountains are common. An estimated 1,076 moose hunters spent $582,178 harvesting 900 moose during the 1965 Wyoming moose season (King, 1966; Walther and Birch, 1966).

Wild Sheep

BIGHORN SHEEP, *Ovis canadensis.* Bighorn sheep are usually found on isolated mountain slopes having sparse growths of trees on rough terrain. At times they may go down to the foothills and plains, but they are never far from ledges, cliffs and steep slopes. In Wyoming, bighorn sheep are restricted primarily, to the Absaroka Mountains, the Wind River Mountains, the mountains surrounding Jackson Hole, the Ferris Mountains, the Seminoe Mountains, the Rattlesnake Mountains, and the Laramie Peak region. Both sexes have true horns but the ewe's are only slender spikes while the ram's are massive horns coiled back, down and then forward. A record horn might reach 49 inches along the horn curve and may have a 16 inch circumference at the base. Bighorn sheep do not have a pelt of wool, but rather have a grayish brown pelt similar to a deer with a denser wooly undercoat. These wild sheep are chiefly grazers feeding on grasses, sedges, and forbs. According to the season, they may browse on twigs of woody plants. In 1965, 291 sheep hunters in Wyoming spent an estimated $170,089 while harvesting 123 sheep (King, 1966; Walther and Birch, 1966).

Bears

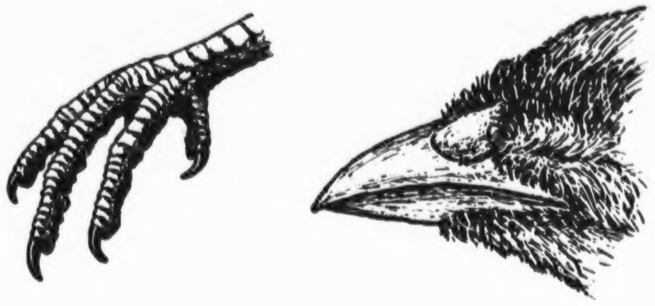
BLACK BEAR, *Euarctos americanus.* Black bears are found in nearly all forested regions of North America. They can usually be found in every wooded mountain area of Wyoming. Both sexes hibernate in Wyoming from November to early April. Bears are omnivorous, eating grasses, forbs, inner bark layers of trees, roots, fruits and other animals, both freshly killed or decomposing carcasses. A total of 328 black bears were harvested during the fall of 1965 and the spring of 1966 (King, 1966).

GRIZZLY BEAR, *Ursus arctos*. The grizzly bear is the largest meat eater or carnivore in Wyoming. Grizzly bears in Wyoming are found only in the high mountains or wilderness areas within and surrounding Yellowstone National Park. Generally, the grizzly bear is more solitary than the black bear. They are very agile with tremendous strength and seem to fear nothing. The grizzly differs in appearance from the black bear by having high humped shoulders and light colored, long and only slightly curved claws. The lack of curved claws is largely responsible for the heavy adults being unable to climb trees. Like the black bear, they too hibernate and their food habits are quite similar. In addition to its esthetic wilderness values, a grizzly bear needs preservation as an economic resource worth $1,000 or more as a trophy skin when hunting is permitted.

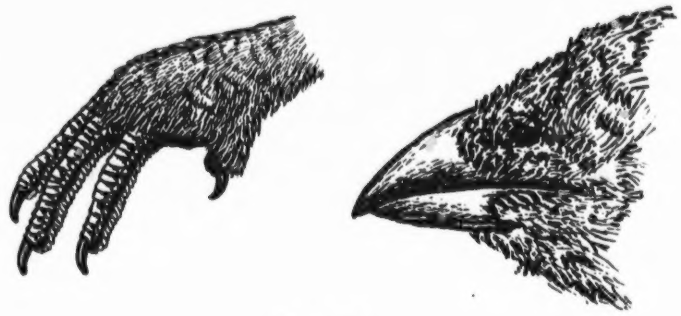
UPLAND GAME BIRDS

Grouse

Wyoming has six species of grouse which are mostly chicken-like ground dwellers, however, several species may climb about in trees and shrubs. The white-tailed ptarmigan, *Lagopus leucurus,* is found on mountain tundras, above timberline with dwarf willows, such as those on Brooklyn Ridge of the Medicine Bow Mountains. The sage grouse, *Centrocercus urophasianus,* dwells in the semi-arid sagebrush plains typical of that around the Farson-Eden region. The sharptailed grouse, *Pedioecetes phasianellus,* lives in the open grassy-brushlands adjacent to forests, of which the Black Hills and the foothills surrounding Sheridan are characteristic. In those middle-aged and younger open stands of aspen, willow, cottonwood, mountain maple, and chokecherry trees, bordered by coniferous forests, characteristic of western Wyoming, one finds the ruffed grouse, *Bonasa umbellus.* In the middle-aged or older spruce forest of the northwestern portion of Teton Mountains one finds the spruce grouse, *Canachites canadensis.* Finally, the most widely distributed forest grouse, the blue grouse, *Dendragapus obscurus,* is found in nearly every coniferous forest area of Wyoming.



Partridge



Grouse

Fig. 36. Contrasting characteristics between a typical grouse (sage grouse) and a typical partridge, quail or pheasant (chukar partridge). Note the feathered and unfeathered nostrils on the bill, the feathered and unfeathered leg, as well as the presence or absence of comblike margins on the toes (Illus. by M. Lester).

Their nostrils and their legs are covered by feathers (Fig. 36). Elaborate courtship displays are characteristic of most grouse. The ruffed grouse cock "drums" while perched on a log to attract a female. The "drumming" noise is produced by rapid flapping of the wings. The sage grouse and sharptail grouse occupy "strutting" or dancing grounds where the cock birds noisily inflate and deflate huge neck air sacs while going through ritualistic movements and displays of erected tail feathers and various body postures to attract hens.

Like the pronghorn, the sage grouse is a heritage unique to Wyoming. Wyoming has more sage grouse than any other state. They are so dependent on sagebrush that without it they will not nest and are unable to raise their young (Patterson, 1952). Large scale destruction of sagebrush can therefore be a major threat to sage grouse welfare.

Quail, Partridges and Pheasants

Not one of these four species of game birds are native to Wyoming. A small population of bobwhite quail, *Colinus virginianus,* has been introduced along the Big Horn River near Kane. The bobwhite quail are typically from the southern and eastern open grassy woodland, or brushland of the United States. A famous game bird, the grey partridge, *Perdix perdix,* came from eastern European areas having cultivated fields of clover, alfalfa and grain. The grey partridge is essentially confined to similar habitat in the northern areas of Wyoming such as the Cody-Lovell region. The chukar partridge, *Alectoris graeca,* is one of the so-called red-legged partridges from the Middle and Far East. It is most abundant along the arid, open, rocky foothills of the Big Horn Basin. Probably the most famous introduced game bird is the pheasant, *Phasianus colchicus,* from open cultivated areas of Central Asia. As in their native land, the major populations are found around productive agricultural cropland such as that of Goshen County and the northern half of the Big Horn Basin.

Most of the quail, partridge and pheasants are birds of the fields and open country. The elaborate courtship rituals of the grouse are not practiced by any of these birds.

Turkeys

The wild turkey, *Meleagris gallopavo,* is native to Wyoming. The Black Hills are typical of the open woodland habitat which supports the largest turkey flocks in Wyoming. Requiring water twice a day, turkeys are never more than 1 or 2 miles from a water source. They are long legged birds having the head and neck bare of feathers. During the day, they spend most of their time on the ground. At night, they roost high up in the trees.

Courtship displays are colorful with the tom spreading his fan-shaped tail while his wings drag on the ground. During this display, his head rests on his shoulder and he makes a puffing sound.

WATERFOWL

The waterfowl are aquatic birds having relatively long necks, blunt and rather spatulate bills with toothlike edges, a body well insulated by down feathers, and all three toes joined by webs. The waterfowl in Wyoming may be classified into three groups on the basis of their feeding behavior: (1) true geese or grazers; (2) surface feeders or puddlers; and (3) divers or bay bucks or pochards.

True geese or grazers

Geese are wary birds which spend less time in the water than do ducks. They are heavier and longer necked than the ducks. Their bills are specially adapted for grazing on grasses and forbs. The legs of a goose are set further forward than ducks, allowing it to walk easier on land while grazing. These birds graze in flocks or "gaggles" and fly in formations called "skeins". The sexes look alike.

Geese may be divided into: (1) grey geese; and (2) black geese. The grey goose species are considered to be the ancestors of the domesticated geese. Two species of grey geese migrate through Wyoming but do not nest here. The whitefronted goose, *Anser albifrons,* is a brownish gray bird with a white face and yellow feet. It may be seen irregularly over most of Wyoming. The snow goose, *Anser coerulescens,* is a white goose with pink legs. It has two color phases, a white phase and a gray or "blue" phase. In either phase, the wing tips are black. The white phase may be seen irregularly over most of the state. The "blue" color phase migrates only through the eastern third of Wyoming.

All black geese have a black neck and head with either a white cheek patch or a white neck patch. The only species of black geese found in Wyoming is the Canada goose, *Branta canadensis.* Large breeding populations of the Canada goose may be found along the Snake River in Jackson Hole, along the Bear River, along the Green River, and on islands in Ocean Lake. Many other Canada geese migrate through Wyoming but do not breed here. Some may stay all winter on the open water found along the Snake River and along the North Platte River near Torrington.

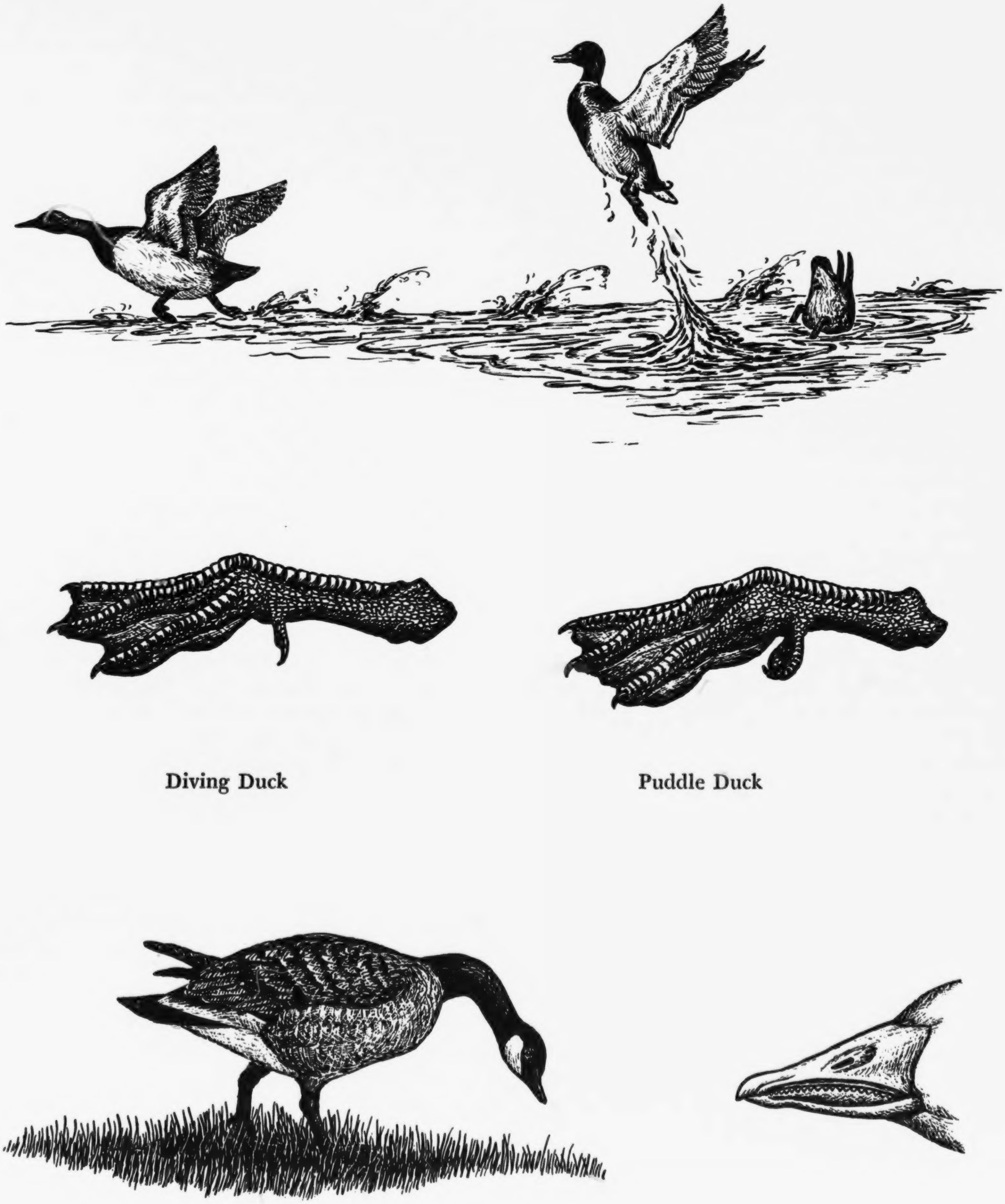
Surface feeders or puddlers

Surface feeding ducks are associated with lakes, ponds, and slow-moving rivers. Their necks and legs are shorter than those of geese. When taking flight from the water they literally jump upward to become airborne (Fig. 37). Most surface feeding ducks have a bright rectangular patch of color (the speculum) on the trailing edge of the wing. The sexes have different colored plumage.

The more common puddling ducks nesting in Wyoming are: the mallard, *Anas platyrhynchos;* the pintail, *Anas acuta;* the gadwall, *Anas strepera;* the American widgeon, *Anas americana;* the shoveler, *Spatula clypeata;* the blue-winged teal, *Anas discors;* and the green-winged teal, *Anas carolinensis.* Of these species, the pintail is probably the most common species, with the mallard close behind. Approximately 75 percent of the duck hunter's bag comes from the surface feeding ducks. Large winter concentrations of mallards may be observed along the Big Horn River between Powell and Kane. Surface feeding ducks feed mostly on aquatic plants, but they will take mollusks, insects, and small fish.

Diving or bay ducks or pochards

All diving ducks, as the name implies, dive for their food from the water's surface. Their legs are set far back on the body and the hind toe is webbed to provide better swimming and diving ability (Fig. 37). They are heavy birds which



Diving Duck

Puddle Duck

Goose

Fig. 37. Comparison between typical diving duck (canvasback), puddle duck (mallard) and goose (Canada goose). Note running takeoff of diver vs jumping takeoff of puddler; webbed hind toe of diver vs unwebbed toe of puddler; and grazing behavior of goose with typical grazing bill characteristic (Illus. by M. Lester).

have to run over the surface of the water before they can become airborne. They eat more animal food than do the surface feeding ducks. Divers lack the colorful speculum present on surface feeders. The more common divers found nesting in Wyoming are: the redhead, *Aythya americana;* the lesser scaup, *Aythya affinis;* and the Barrow's goldeneye, *Bucephala islandica.* Migrant divers passing through but not nesting in any significant numbers in Wyoming are: the canvasback, *Aythya valisineria;* the common goldeneye, *Bucephala clangula;* and the bufflehead, *Bucephala albeola.* Of all these divers, the lesser scaup is probably the most abundant migrant, as well as the most common nesting species.

Generally, divers spend the winter in large groups or "rafts" in protected bays and river mouths of the coastal regions. During the 1965 bird hunting season, direct expenditures by Wyoming bird hunters amounted to 2.9 million dollars.

SMALL GAME

Cottontail Rabbits

The smallest and most abundant mammals listed as game animals are the cottontail rabbits. They provide more hunting than all the big game species together. Every year the combined harvest of cottontails in Michigan, Pennsylvania and Missouri fluctuates between 9 and 15 million animals. In Wyoming, the cottontails have only recently received recognition from the sportsman that they are a valuable wildlife resource.

While three similar species of cottontails are found in Wyoming, only two species are generally distributed over the state. The common names are helpful to separate the three species. The eastern cottontail, *Sylvilagus floridanus,* is found only at a few places along the eastern border of Wyoming. It lives along the edge of heavy brush or forest strips adjoining open field or grassland areas at the lower elevations of the state. The desert cottontail, *Sylvilagus auduboni,* is found statewide on the lower arid plains, valleys, and foothills predominantly vegetated with various combinations of grass, sagebrush, greasewood, and pinon-juniper trees. It has larges ears than do the other two species. The mountain cottontail, *Sylvilagus nuttali,* as the name implies, is found at or above those highest elevations occupied by the desert cottontail. It may even be found at elevations slightly over 11,000 feet. Brushy areas of sagebrush, wild roses, wild gooseberries, etc. amongst rocks or near rocky areas are choice habitat for this species.

In general, cottontails feed on a wide variety of grass and forbs in the summer. As frosts destroy the green vegetation, the cottontail gradually shifts to his winter diet, consisting of bark and twigs of deciduous woody species, as well as, buds and needles of some coniferous trees. While rabbits reproduce very rapidly with several litters of young each year, the annual increase is usually lost every year. Around 35 percent of the young are lost before they leave their nest.

GAME FISH

The game fish of Wyoming consist of: (1) cold-water fish; and (2) warm-water fish. The low temperatures of a majority of Wyoming's streams, rivers and lakes favor the dominance of the cold-water fisheries over the warm-water fisheries.

Cold-water Fish

Cold-water fish include those species inhabiting waters whose summer temperatures range between 54°F and 65°F (Simon, 1946). In those waters colder than 42°F for extended periods, growth and reproduction are poor. The trout, grayling, and whitefish are typical cold-water fish. All of these fish have cycloid scales, a body shape which is elliptical to oval in cross section and possess a fleshy adipose fin (Fig. 38).

Of the six species of trout found in Wyoming, only the cutthroat trout, *Salmo clarki,* is a native trout; large populations are still maintained in the Snake and the Yellowstone River drainages. The brown trout, *Salmo trutta,* is a native of Europe and currently is widely distributed in the state. Brown trout are very tolerant of periodic warm water temperatures, up to 80°F, and are very wary of the fisherman's hook. Some of the best brown trout populations are found in the North Platte River near Saratoga and in the Laramie River.

The rainbow trout, *Salmo gairdneri,* is a native of the streams flowing from the Pacific Coast into the ocean. It is probably the most abundant trout in Wyoming, having been planted throughout the state. Their fine sporting qualities and easier catchability accounts for the fisherman's preference for this species. This hardy, fast growing species is also one of the easiest to propagate artificially. Excellent rainbow trout populations are present in the North Platte River near Saratoga and in the Wind River above and below Boysen Reservoir and in reservoir lakes.

The brook trout, *Salvelinus fontinalis,* was native to the drainages of the eastern U.S. They are a very popular fish in Wyoming, because the novice can catch them readily. Usually,

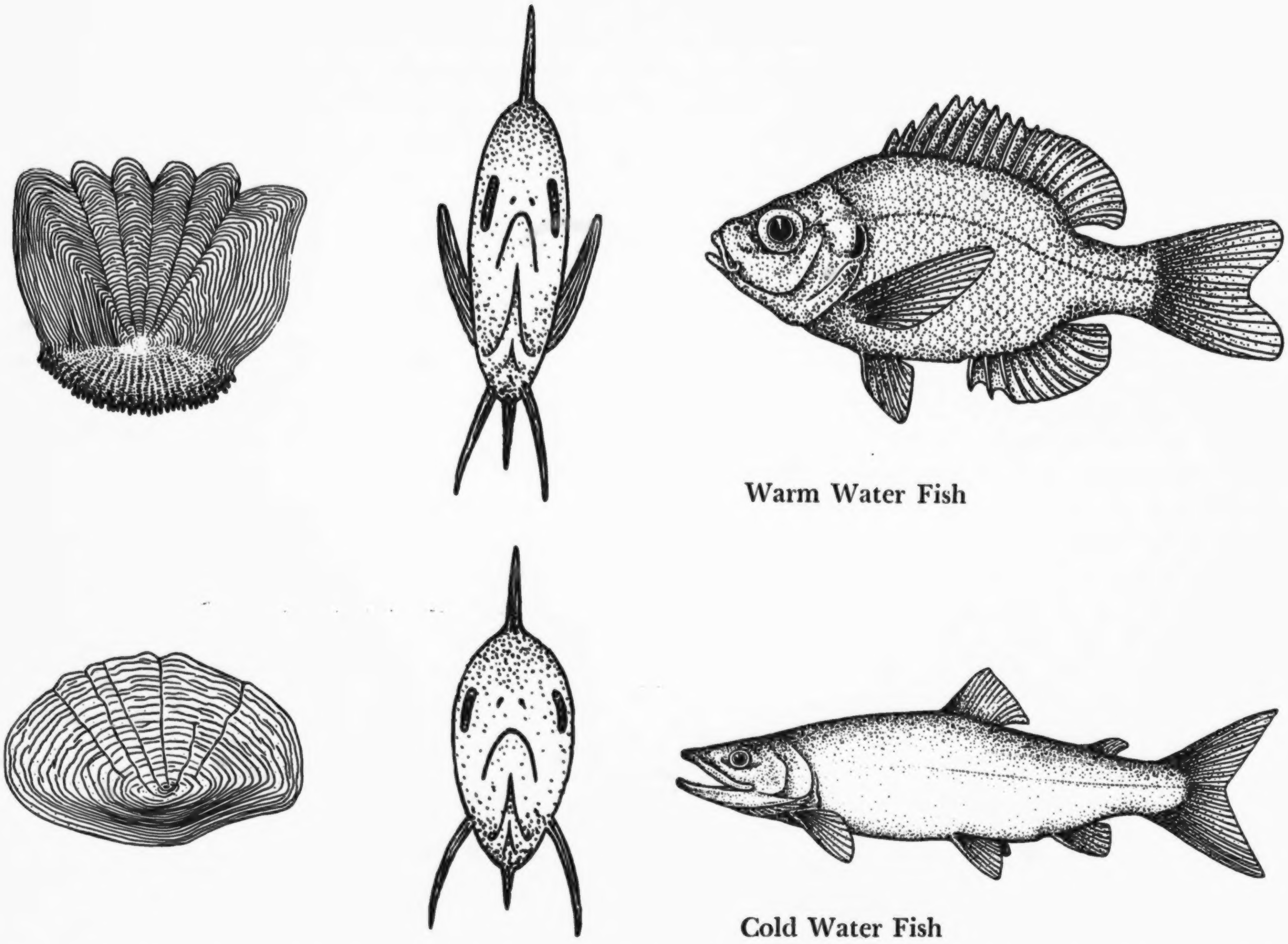


Fig. 38. Comparison of body shape between typical warm-water fish, (crappie) and cold-water fish (lake trout). Note also the presence of the small, fleshy adipose fin on the back of the lake trout between the dorsal fin and the tail. The warm-water ctenoid scale and the cold-water cycloid scale differ markedly (Illus. by M. Lester).

one finds the brook trout in ponds, lakes, and beaver ponds in any part of the state above 6,000 feet where cold water is abundant and well oxygenated. Because of its ability to successfully spawn where other trout fail, the brook trout frequently over populates its habitat, with resulting populations consisting of many stunted fish.

Probably the most colorful of the trout is the golden trout, *Salmo aguabonita,* originally from lakes at 10,000 feet or more in the Southern Sierra Nevada Mountains of California. Being able to live on microscopic plants and animals, this species is best adapted to rock bound lakes above 10,000 feet in elevation. Famous golden trout fisheries are located in Cook Lake and Washakie Lake in the Wind River Mountains and Lake Christine in the Big Horn Mountains.

The largest member of the trout family is the mackinaw or lake trout, *Salvelinus namaycush.* A native of the Great Lakes, New England and eastern Canada, this species has been planted in many deep, cold-water lakes in Wyoming. The best populations have developed in Jackson Lake and Fremont Lake. The lake trout prefers water temperatures of 60°F or colder and moves from surface waters occupied in the winter and spring, into deep colder waters in the summer and early fall.

The Rocky Mountain whitefish, *Prosopium williamsoni,* is a native species widely distributed in the state's major cold-water streams west of the Continental Divide. It is becoming more important as a game and food fish, despite its competition with trout for both food and space. It has a very small, delicate mouth and hence is difficult to hook or land in comparison to trout. The best catches of whitefish are made in winter. Often confused with the whitefish is the arctic grayling, *Thymallus arcticus.* It has a very large dorsal fin, a trout-like head and a silvery scaled body similar to the whitefish. The fish is unable to stand intensive fishing pressure and is only found in a few lakes in Wyoming, such as Meadow Lake in the Wind River Mountains and Willow Lake in the Big Horn Mountains.

Warm-water Fish

Warm-water fish include those species inhabiting water whose summer temperatures range from 65°F to slightly over 75°F (Simon, 1946). All of the warm-water fish have ctenoid scales and a body shape which is less elliptical and more thin and deep-bodied than trout in cross section. They all lack the adipose fin. (Fig. 38).

The walleye, *Stizostedian vitreum,* is a perch which has been successfully planted in several reservoirs in the state. It is a native of Canada and the eastern half of the United States. Generally, they have been difficult to catch, but are prized for their food qualities. Some of Wyoming's best walleye fisheries are located in Boysen Reservoir and in Keyhole Reservoir. Often confused with the walleye, the sand pike or sauger, *Stizostedian canadense,* is actually a smaller and more slender perch. Originally native to the North Platte and Big Horn Rivers, the major population is now found in Boysen Reservoir. Another member of the same family, the yellow perch, *Perca flavescens,* is a widely introduced species which has become a problem for fish management. The yellow perch reproduces very rapidly and produces stunted populations which seriously compete for food with other species of game fish. They can be caught with almost any lure, but their small stunted size is detrimental to their becoming a desirable game fish.

Several sunfish have had only limited success in Wyoming's cold waters. The largemouth bass, *Micropterus salmoides,* and the green sunfish, *Lepomis cyanellus,* have had an advantage of greater tolerance to a wider range of water temperatures than other members of this family. Unfortunately, the green sunfish never reaches a size which makes it very desirable as a game fish. It does, however, compete with the largemouth bass for both space and food. The bluegill, *Lepomis macrochirus,* has been restricted because few water areas have a temperature of 80°F for extended periods in the summer during the spawning period. The same problem confronts the black crappie, *Pomoxis nigromaculatus.* Limited as they are, good populations of largemouth bass and bluegill can be found in Ocean Lake and Festo Lake. Black crappie populations are well established in Lake DeSmet and Ocean Lake.

One of the better warm water food fish, which is not widely distributed in Wyoming, is the channel catfish, *Ictalurus punctatus.* Populations of channel catfish are developing in the Belle Fourche River, lower Powder River and to a smaller extent in the lower Little Snake River.

A native codfish, the ling or burbot, *Lota lota,* has been successful in maintaining itself in only a few areas. Snake-like in appearance, these fish in Wyoming are valued for their food qualities. Harvest of ling is best achieved through the ice with setline. Excellent ling fishing may be found at Ocean Lake and Boysen Reservoir.

Direct expenditures attributable to fishing by 151,057 fishermen in 1965 is estimated to have amounted to 23.3 million dollars (Young, 1966· Walter and Birch, 1966).

ADMINISTRATION

Ever since colonial times, the game and fish resources have been designated as property held in trust for the public by their government. No individual could establish a property right on a wild game or fish species. This concept has been upheld by courts of law to the present time. To assume this responsibility, Wyoming initially appointed a State Fish Warden in 1879 for the purposes of raising and planting fish for Wyoming's waters. In 1899, the State Game Warden position was authorized for the purpose of achieving better enforcement of game laws. Not until 1925 was a six man Game and Fish Commission established. Various changes since that time have established the Commission as a seven member body appointed by the Governor with the advice and consent of the Senate, plus the Governor as an ex-officio member. No more than four of the appointed members may be of the same political party.

The Commission's function is two fold; (1) it serves as a buffer against political interferences with sound management of the fish and game resources; and (2) it establishes the policies for management of Wyoming's game and fish resources. The actual management of these resources is the responsibility of the Director of the Department and the personnel he supervises. The Department is organized into five divisions: (1) the Office and Fiscal Division is responsible for all transactions involving license sales, revenue, receipts, and fund expenditures; (2) the Game Division is responsible for the enforcement of game and fish laws and the management of the game species; (3) the Fish Division is responsible for the management of wild fisheries as well as artificially raised fish; (4) the Technical Services Division is responsible for basic game and fish research, habitat and land development, engineering, land administration and public access development; and (5) the Information and Education Division is responsible for Department publications and information and education services for schools, public meetings, radio, television, and newspapers.

MANAGEMENT

Game and fish are a product of Wyoming's land and water. Every area is able to support only a limited number of these animals. Any population increase beyond that limit cannot be sustained. This natural restriction of animal numbers has been called the carrying capacity. Carrying capacity is then a function of good or bad habitat. The welfare of our game and fish resources is primarily determined by any beneficial or detrimental changes in the land or water habitats.

Management of a game and fish resource is not unlike the management of a livestock enterprise. Three fundamental objectives are common to both. First, it is desirable to maintain a long term, stable operation. This implies the successful transfer of our game and fish resource to succeeding generations in a condition not too different from what we now know it to be. Secondly, a balance between game and fish numbers and the feed available to them must be maintained. The carrying capacity of a stream, a grassland, etc., must not be exceeded. Lastly, a maximum annual harvest of surplus game and fish must be achieved. If too few animals are harvested, the carrying capacity is exceeded and losses of animals and habitat, as well as, other resources will result. If too many animals are harvested, the full potential of the habitat to produce game and fish cannot be realized.

While roughly half of our state consists of public lands, recognition of the important role of privately owned lands for wildlife production is necessary. If the private landowner provides space and resources for wildlife use or is to provide access across private land to public land, the public must recognize the rights of a landowner. Entering upon land without permission is trespassing and is forbidden by law. Damaging private property by littering, leaving gates open, shooting livestock, abusing or destroying private property must be eliminated. Hunting and fishing use of land should not be a burden on those who own the land.

Conversely, recognition by the land manager

Table 7. HUNTING AND FISHING EXPENDITURES BY COUNTY IN WYOMING DURING 1965 (Walther and Birch, 1966)

CLASSIFICATION	RESIDENT EXPENDITURES	% OF TOTAL	NONRESIDENT EXPENDITURES	% OF TOTAL	TOTAL SPENT	% OF TOTAL
Natrona	$ 6,209,978	18.61	$ 828,698	3.45	$ 7,038,676	12.27
Laramie	5,447,490	16.33	72,303	.30	5,519,793	9.62
Sheridan	1,816,418	5.44	884,316	3.68	2,700,734	4.71
Sweetwater	2,338,314	7.01	439,377	1.83	2,777,691	4.84
Albany	652,788	1.96	533,926	2.22	1,186,714	2.07
Carbon	1,520,638	4.56	2,508,342	10.45	4,028,980	7.02
Goshen	1,279,215	3.83	66,741	.28	1,345,956	2.35
Platte	421,358	1.26	111,235	.46	532,593	.93
Big Horn	1,368,918	4.10	422,692	1.76	1,791,610	3.12
Fremont	3,321,347	9.96	1,129,032	4.70	4,450,379	7.76
Park	1,827,001	5.48	1,852,057	7.72	3,679,058	6.41
Lincoln	514,938	1.54	2,358,175	9.82	2,873,113	5.01
Converse	258,867	.78	261,401	1.09	520,268	.91
Niobrara	239,883	.72	194,661	.81	434,544	.76
Hot Springs	630,578	1.89	55,617	.23	686,195	1.19
Johnson	784,586	2.35	1,062,291	4.43	1,846,877	3.22
Campbell	200,195	.60	700,778	2.92	900,973	1.57
Crook	472,138	1.42	739,711	3.08	1,211,849	2.11
Uinta	945,783	2.83	44,494	.19	990,277	1.73
Washakie	903,319	2.71	111,235	.46	1,014,554	1.77
Weston	352,862	1.06	189,100	.79	541,962	.94
Teton	832,481	2.50	5,862,068	24.43	6,694,549	11.67
Sublette	902,118	2.70	3,170,188	13.21	4,072,306	7.10
Yellowstone	119,866	.36	406,007	1.69	525,873	.92
Total	$33,361,079	100.00	$24,004,445	100.00	$57,365,524	100.00

and land owner that on many areas, wildlife values exceed the values of other land uses is important if our wildlife heritage is to survive. It must be recognized that the amount of lands or waters strictly devoted to wildlife will be rather small. A high percentage of game and fish will be from lands and waters devoted to several uses. The increased demand for hunting and fishing space has created real economic competition with these other uses.

Evaluation of the benefits of game and fish resources from an economic aspect is something everyone understands. Table 7 presents a summary of the direct hunting and fishing expenditures by county in Wyoming during 1965. However, how much has it been worth to a tourist from New York City to see antelope for the first time or to have seen the strutting of sage grouse for the first time? Are these intangible values the same ones that cause a rancher to protect his pet deer or antelope around the ranch house?

We have in Wyoming a relatively unexploited game and fish resource. This should not lead us to a sense of false security in safeguarding that valuable heritage. Walther and Birch (1966) commented on this problem with respect to economic considerations, however, their statement is appropriate for every real or abstract value game and fish might have.

> As long as all participants are reasonable in the varying phases of exploitation, it is obvious that hunting and fishing is—and will continue to be—a major resource of the state. If hunting and fishing become to restrictive or too expensive then everyone from the landowner to the resident and nonresident hunters and fishermen have a lot to lose as does almost the whole spectrum of consumer enterprises operating in the state

Every citizen should consider that, as with other species of wildlife, how we use the land, not just the hunting and fishing, is a matter of life and death for our game and fish resources.

Acknowledgments

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Outdoor Recreation

JAMES SIMON[19]

Every variety of sport and outdoor activity identified with a temperate climate may be enjoyed in Wyoming, and there are numerous activities for each season of the year.

Wyoming has two major vacation attractions of world-wide renown: Yellowstone National Park and Grand Teton National Park. In addition, there are nine national forests, all or part of which are in Wyoming. There are two national monuments, two national recreation areas, ten state parks (Fig. 39), 20 thousand miles of fishable streams, 5 thousand lakes and over 17 million acres of additional public lands. There are 300 significant historical sites, marked by monuments or signs, describing the events which took place in early Wyoming, plus hundreds of historic trail markers. It is also significant that Wyoming has a number of firsts in outdoor recreation resources. The first national park of the nation, Yellowstone National Park, the first national monument in the nation, Devils Tower and the first national forest in the United States, Shoshone National Forest, were established here.

Excellent routing and first-rate highways allow easy access across and to all sections of the state. There are excellent state primary and secondary routes in all parts of the state, also excellent county roads to allow access to the back country.

Recreation based on the rivers, lakes and reservoirs is important. Fishing leads the list of water sports in popularity, while water skiing, river float trips, and many others are of value in rounding out the vacation of the visitor to Wyoming. Skiing, snowmobiling, fishing, and other activities make winter important to the vacationer. As befits a western state, some vacation activities revolve around the horse—pack trips and horseback riding. Hunting, of great variety, is an important form of recreation in the fall. Miscellaneous activities include such widely different efforts as mountain climbing and nature study.

Scenic attractions and outdoor recreation in which the tourist participates himself are not the only attractions in Wyoming. Various spectator sports and other events are of prime importance. Between March and September of 1966, 96 events were scheduled, including rodeos, pageants, horse shows, fairs and local celebrations (Wyo. Travel Comm., 1966a). Ski meets, snowmobile rendezvous and cutter races in recent years have also attracted thousands of people from out-of-state.

Some summer events are widely known: All American Indian Days at Sheridan, Gift of the Waters Pageant at Thermopolis, Green River Rendezvous at Pinedale, Central Wyoming Fair and Rodeo at Casper, Wyoming State Fair at Douglas and the One Shot Antelope Hunt at Lander. One event in a class by itself and known the world over is the "The Daddy of 'Em All"—Cheyenne's Frontier Days.

Value of Tourism

A "visitor" is anyone coming into the state, or anyone bringing to Wyoming the "new dollar", and may be either a traveler or tourist. The "traveler" is one who comes into Wyoming and

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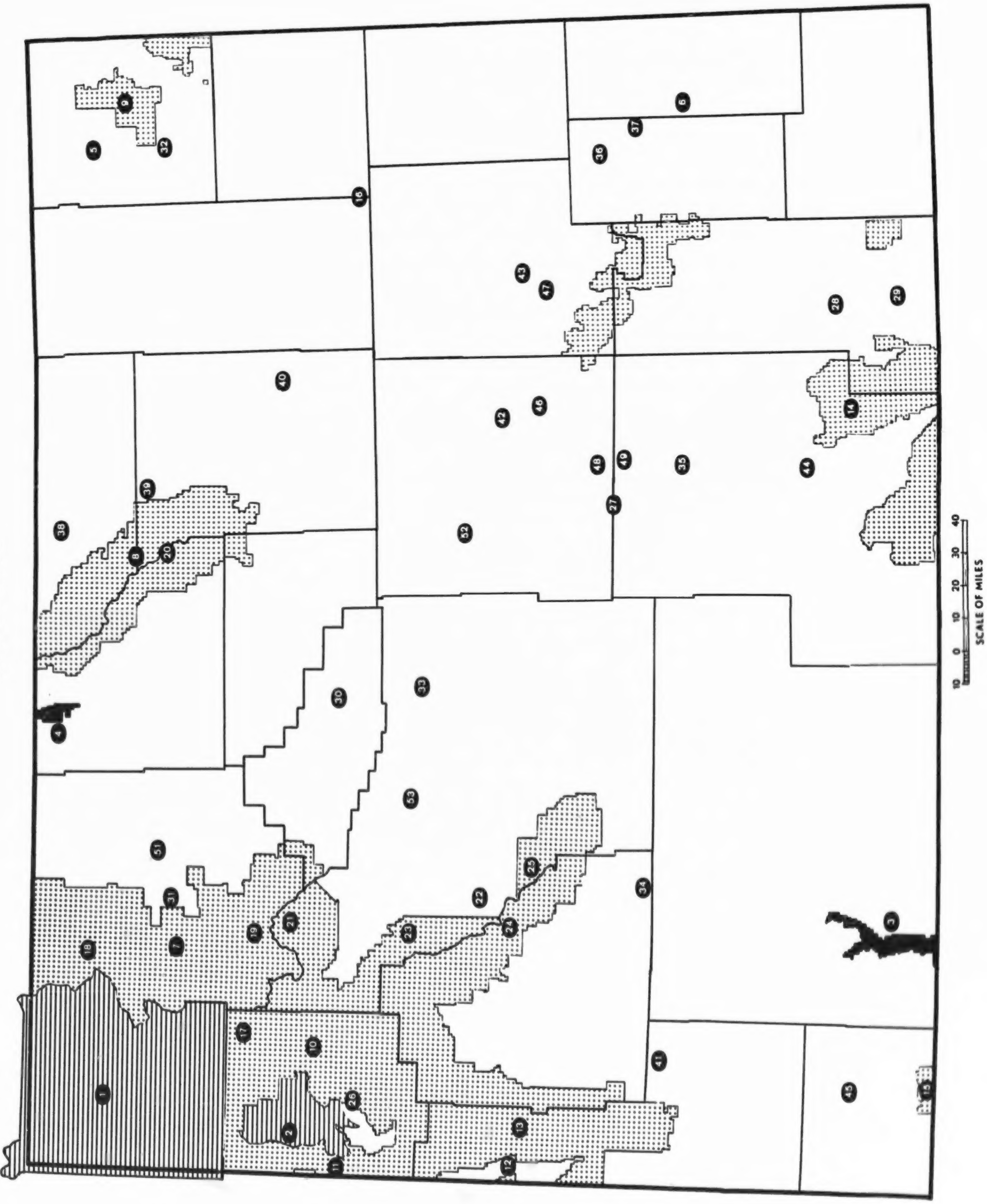
[19] Assistant Director, Wyoming Travel Commission, Cheyenne.

WYOMING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Place	Acreage	County
FEDERAL		
Parks:		
1. Yellowstone National Park	2,039,217	Park, Teton
2. Grand Teton National Park	302,443	Teton
Recreation Areas:		
3. Flaming Gorge National Recreation Area	103,680	Sweetwater
4. Big Horn Canyon National Recreation Area		Big Horn
Monuments:		
5. Devil's Tower National Monument	1,267	Crook
6. Fort Laramie National Historic Site	192	Goshen
Forests:		
7. Shoshone National Forest	2,430,028	Hot Springs Sublette, Teton, Fremont, Park
8. Big Horn National Forest	1,113,768	Johnson, Washakie Big Horn, Sheridan
9. Black Hills National Forest	199,466	Crook, Weston
10. Teton National Forest	1,700,766	Lincoln, Park, Fremont, Sublette
11. Targhee National Forest	344,573	Lincoln, Teton
12. Caribou National Forest	7,829	Lincoln
13. Bridger National Forest	1,699,878	Fremont, Teton, Lincoln, Sublette
14. Medicine Bow National Forest	1,069,283	Converse, Platte, Natrona, Albany, Carbon
15. Wasatch National Forest	36,880	Uinta
16. Thunder Basin National Grassland	1,069,084	Campbell, Converse, Weston, Niobrara
Wilderness Areas:*		
*Parts of National Forests		
17. Teton Wilderness Area	563,000	Teton, Park, Fremont
18. North Absaroka Wilderness Area	359,700	Park
19. South Absaroka Wilderness Area	506,300	Park
20. Cloud Peak Wild Area	94,000	Johnson
21. Stratified Wilderness Area	147,000	Fremont
22. Wind River Mountains Roadless Area	183,520	Fremont
23. Glacier Wilderness Area	177,000	Fremont
24. Bridger Wilderness Area	383,000	Sublette
25. Popo Agie Wild Area	70,000	Fremont
Wildlife Areas:		
26. National Elk Refuge	23,790	Teton
27. Pathfinder National Wildlife Refuge	46,341	Carbon
28. Bamforth National Wildlife Refuge	1,166	Albany
29. Hutton Lake National Wildlife Refuge	1,968	Albany
STATE		
Parks:		
30. Hot Springs State Park	640	Hot Springs
31. Buffalo Bill State Park	12,716	Park
32. Keyhole State Park	14,324	Crook
33. Boysen State Park	42,366	Crook
34. Big Sandy State Park	5,180	Fremont
35. Seminoe State Park	37,944	Sublette
36. Glendo State Park	24,036	Platte
37. Guernsey State Park	9,200	Platte
Monuments: Historic		
38. Connor Battle Field State Park	12	Sheridan
39. Fort Phil Kearny Historic Site	3	Johnson
40. Fort Reno Historic Site	14	Johnson
41. Names Hill Historic Site	4	Lincoln
42. Red Buttes Battlefield	30	Natrona
43. Fort Fetterman Historic Site	40	Converse
44. Platte River Crossing	8	Carbon
45. Fort Bridger State Park	37	Uinta
MAJOR LOCAL		
Parks:		
46. Casper Mountain Park	480	Natrona
47. Ayer's Natural Bridge	14	Converse
48. Alcova Lake	6,120	Natrona
49. Pathfinder		Natrona
50. Gray Reef		Natrona
Monuments: Scientific		
51. Spirit Mountain Cavern	210	Park
52. Hell's Half Acre	320	Natrona
53. Wind River Indian Reservation	1,800,000	Fremont

Fig. 39. Type, location and size of Federal, State and Local outdoor recreational facilities in Wyoming.

moves about or one who passes through to another destination on business or other activity not having to do with vacations. The "tourist" has a destination in Wyoming or stops to visit the scenic or recreational attractions, although his final destination for the whole of the trip may be in another state. The tourist may be identified with one using leisure time.

Travelers use many of the same goods and services as the tourist: filling stations, motels, hotels, restaurants, grocery stores and other retail purchases, professional men, etc. Tourist goods and services amount to 26 dollars per day for a party of 3.6, as indicated by the University of Wyoming Survey (*Wyoming Trends,* 1965). A trailer party of any number of people spent 20 dollars a day according to the same survey.

Larson (1965) states that out-of-state visitors spent 107 million dollars in Wyoming in 1963. Rather than place a flat dollar value on the tourist business in Wyoming, the travel industry would prefer to indicate a percentage increase from year to year. The University of Wyoming data indicate there has been an average gain of 5.96 percent each year from 1960 through 1965 (*Wyoming Trends,* 1965). Lund (1960) states that visitors and truckers contributed 10.6 percent of Wyoming's entire basic income during 1960. Lund (1963) and Larson (1963) consider travel to be the third largest of Wyoming's industries. Lund (1960) lists these totals for income from the four state industries of Wyoming: Mineral production (including oil and gas), 400 million dollars; agriculture, 150 million dollars; tourism, 78.5 million dollars; manufacturing, 50 million dollars.

Lund (1964) also estimates the number of families in Wyoming supported by the visitor industry are:

> "In comparing the travel business to the rest of the state's industries, some interesting figures arise. Census of population data show total employment, including owner-operators for agriculture, to be 15,439 persons and minerals (non-manufacturing) to be 8,851 persons in 1960. Wyoming Employment Security Commission data show average yearly hired employment for lodging, cafes and gas stations to be 8,500 persons. Records at the Division of Business and Economic Research at the University of Wyoming show that an extra 2,000 owner-operators should be added for a total of 10,500 persons. Now for some educated guessing—we would say that about two-thirds of the above employment would be associated with out-of-state visitors; also, we can add some employment from other retailing and service activity. The result: we would estimate that 9,000 to 10,000 families are provided employment by the visitor industry in Wyoming."

Accommodations

A wide variety of accommodations for the visitor exists in Wyoming. In 1966, 565 motels, 137 hotels, 61 resorts, 92 dude ranches and 357 outfitters were operating in Wyoming (Wyo. Travel Comm., 1966b).

Campgrounds and trailer courts are divided as follows: Privately operated, 114; U. S. Forest Service, 123; National Park Service, 32; Game and Fish Department, 10; State Parks, 9; Natrona County Parks Board, 5; Bureau of Land Management, 4. As expected, the privately operated units are mostly improved trailer courts, while those managed by public agencies tend toward regular campgrounds with spaces for self-contained trailers and campers.

Although some of the dude ranches, resorts and lodges approach the complete resort concept, Wyoming is not a resort area in the literal sense. Wyoming visitors are most often on their own to seek out areas and accommodations which they like. They avoid the organized activities which are the earmark of a resort.

STATE OF WYOMING

Wyoming Recreation Commission

The 1967 Wyoming Legislature combined the Land and Water Conservation Commission with the Parks Commission to form the Recreation Commission. This commission consists of one member from each of the nine Judicial Districts and the Governor who serves in an ex-officio capacity.

The commission's general responsibilities include the preparation and maintenance of a comprehensive plan for the acquisition and development of Wyoming's outdoor recreation resources. Outdoor recreation resources include state parks, public recreation grounds, historical landmarks, and historical, geological, and ecological sites. Further responsibilities include development, operation, and maintenance of outdoor recreation areas and facilities, and acquisition of land and water.

A major statewide grants-in-aid program for outdoor recreation will be administered by this commission. Under the Federal Land and Water Conservation Act, 4.6 million dollars will be allocated to Wyoming between 1965 and 1970. These funds are derived from visitor use fees, such as those paid for the Federal "Golden Passport" which allows visitor use of Federal outdoor recreation facilities.

The State Parks System is composed chiefly of reservoirs whose primary purpose is storage of water for irrigation purposes and production of power. Reservoir draw-down, silting and cyclic changes in the organic content of these water bodies cause difficulty for the administrative agency. Since each reservoir is a part of a larger system, none can be managed efficiently for its recreational uses without interfering with the primary purpose of the reservoir involved. Thus, each of the reservoir parks is useful only a small part of the year, generally the spring or early summer months and possibly a few weeks in the winter, for fishing and other recreational uses. Management of fish in these areas is extremely difficult because of the cyclic changes in organic content of the water. There can be no sustained fish yield over the years, nor can fisheries managers create long term plans of management because of the reservoir's primary use, irrigation and power (Fig. 40).

Many other state parks exist in Wyoming as created by the legislature, but are not of major importance and serve only to cause confusion when listed along with the larger parks. It would be desirable, in the future, to diversify the State Parks System, and bring into it some of the desert areas, river areas, plains areas and certain canyon areas without reservoirs.

The Hot Springs State Park at Thermopolis is not part of the State Parks System since it is administered by the State Board of Charities and Reform.

Wyoming Travel Commission

This agency is set up by law for the purpose of advertising Wyoming's attractions. Recreation

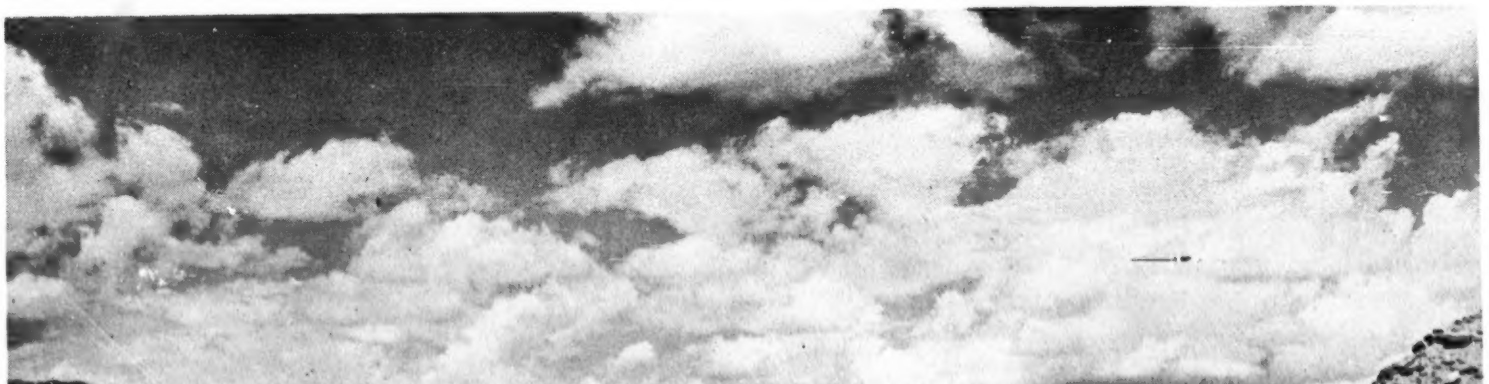

Fig. 40. Alcova Reservoir southwest of Casper on the North Platte River (Wyo. Travel Comm. photo).

and scenic attractions are given first attention. However, the Travel Commission is also required to give attention to agricultural and industrial promotion. The State Legislature appropriates funds to promote Wyoming through: (1) national advertising in magazines, newspapers and over radio and television; (2) travel shows; (3) intrastate activities with businesses and communities; (4) production and distribution of motion pictures and still photographs; (5) advertising special events; and (6) advertising designed to extend the travel season.

Wyoming Game and Fish Commission

As attractions to the visitor and as additional outdoor activities for its own residents, hunting and fishing have especially great value to Wyoming. The volume of hunting and fishing activity can be indicated by the 1965 license sales. Combining 36 types of licenses and permits the following summary is given:

Resident fishing	73,771
Non-resident fishing	73,203
Resident hunting	95,893
Non-resident hunting	57,909
Non-resident hunting and fishing	4,000

Fishing is no longer strictly a seasonal sport. Because it can be indulged in at all times of the year, it is valuable in extending the tourist season. Winter fishing fits into the overall development of well-rounded winter recreation areas. Spring fishing in April and May takes up the slack during a period of the year when winter sports are finished and before the real visitor season has begun.

Because of hunting, service businesses can extend their services from September through November during the hunting season.

Approximately 50,000 acres of land are owned by the Game and Fish Commission; they are primarily used for 14 winter pastures or winter ranges for big game. Twelve public fishing areas, about 60 miles of stream and some irrigation reservoirs are usually managed by cooperative agreements or easements. Seven fish rearing stations and hatcheries, four game management units, two public hunting areas and one big game research area are also part of the department's management program. Ten overnight campgrounds and a number of picnic areas and rest stops are provided in the foregoing management areas.

FEDERAL GOVERNMENT

U.S. Department of Interior

U.S. Bureau of Outdoor Recreation. The Bureau of Outdoor Recreation is a national outdoor recreational planning agency. Under provisions of the Land and Water Conservation Act it serves to coordinate long range state outdoor recreation planning programs and allocates Federal Land and Water Conservation Funds to approved state outdoor recreation projects. These land and water conservation act funds are derived from the sale of the Golden Passport ($7 per year) which permits entrance to any national park, forest, wildlife refuge and other federal recreational areas. Other limited use permits are sold under this program for lower fees. Such funds allocated to Wyoming are administered by the Department of Recreation.

National Park Service. This agency manages national parks, Yellowstone and Grand Teton; national monuments, Devils Tower (Fig. 41) and Fort Laramie (although the latter is more correctly a national historic site); and national recreation areas, Flaming Gorge (Fig. 42) and Big Horn Canyon. These six areas total 2.3 million acres. From January 1, to November 1, 1966, Yellowstone had 2.1 million visitors. By October, 1966, Grand Teton had admitted 2.5 million visitors in that calendar year, a gain of 7.7 percent over the previous year. The new Flaming Gorge area (from the Wyoming side only) had 382,621 visitors for an increase of 56 percent over 1965. Yellowstone has the world's greatest number of thermal areas, including geysers, hot springs and numerous other forms of thermal activity. Of these, Old Faithful is the most famous, however, Castle and Grott Geysers, Lone Star Geyser, Pink Dome Geyser, and many others are popular. Mammoth Hot Springs geyserite terraces are also outstanding.

Yellowstone Falls, both upper and lower, Tower Falls, Lewis River Falls, Beckler River, and many other scenic river areas belong to the Yellowstone National Park River System. The Lewis River is one of the headwaters of the Snake; the Yellowstone River is one of the headwaters of the Mississippi.

The rivers and falls are, of course, frequently associated with picturesque canyons; Grand Canyon of the Yellowstone and Lewis River Canyon being good examples. Natural bridges and petrified trees add to the interest of this area. Fishing is excellent and artificial stocking of the native species of trout is not required. Except for the imprint of human travel and occupancy on 5 percent or less of its area. Yellowstone is a wilderness park.

It is the largest wildlife refuge in the continental United States. Most visitors can see black bears, elk, mule deer, coyotes, many forms of

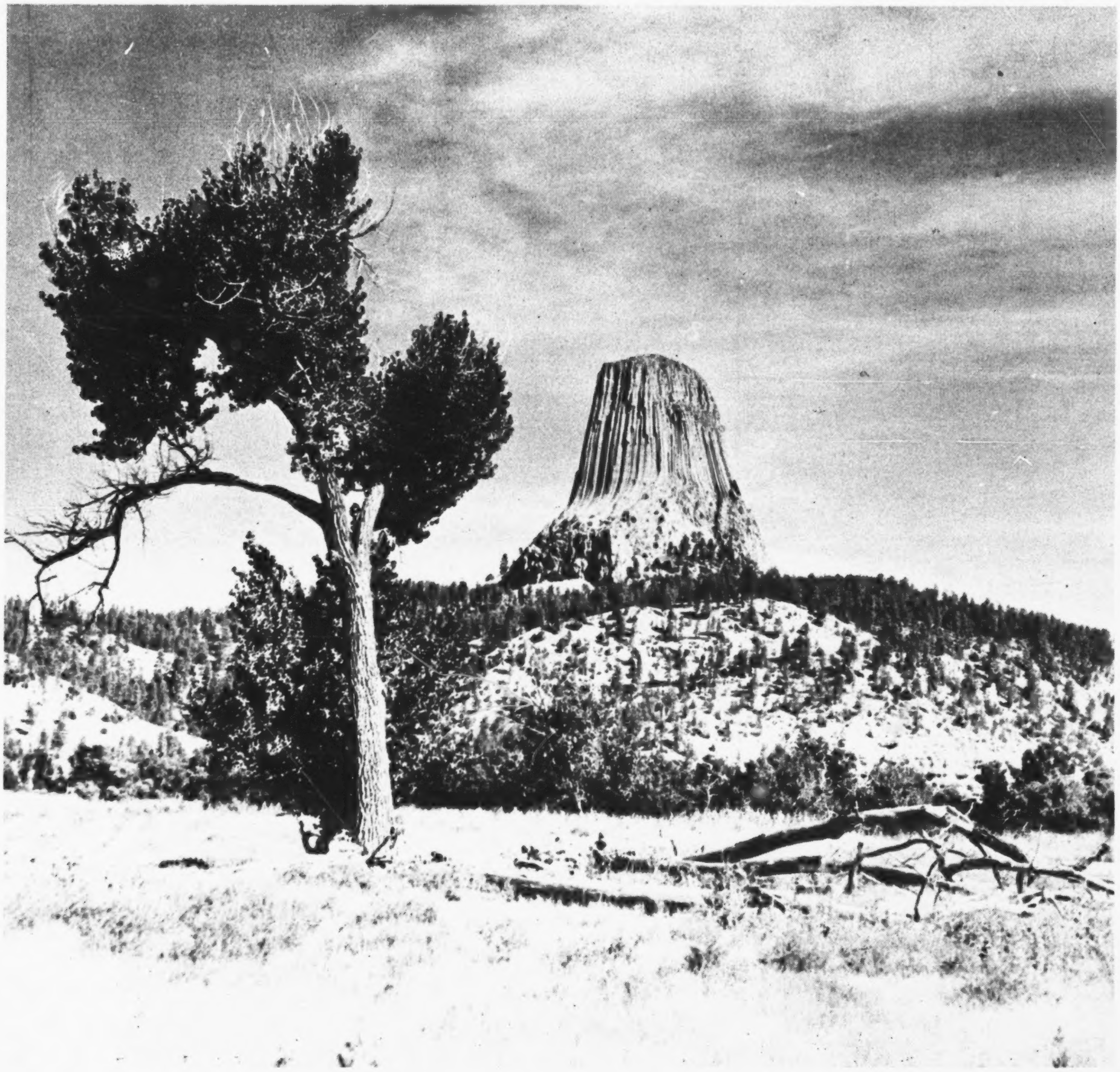

Fig. 41. Devils Tower (865 feet tall with a top diameter of 275 feet and a basal diameter of 1,000 feet), Devils Tower Monument (Wyo. Travel Comm. photo).

water birds (including the rare trumpeter swan), Canada geese, many varieties of ducks and song birds. Smaller mammals are also evidenced: badgers, the yellowbelly marmot, golden-mantled ground squirrel, Unita ground squirrel and a number of species of chipmunk. However, Pine Marten, although abundant, are rarely seen and most visitors are very fortunate to have the opportunity to view the extremely rare grizzly bear.

Wyoming's wildlife is often described in relation to Yellowstone National Park. But it should be remembered wildlife is not limited to Yellowstone National Park, but is abundant in other parts of Wyoming—other park areas, national forests, public lands and privately owned properties.

Grand Teton National Park counts first among its natural attractions the towering Teton Range, especially the Grand Teton itself. Grand Teton National Park is also large enough to be ranked as a wildlife refuge. In addition to the wildlife and mountains, there are mountain lakes of extreme beauty, such as Jackson Lake, and one of America's great rivers, the Snake.

Bureau of Land Management. This agency is charged with the management of 17.4 million acres of land in Wyoming, used principally for grazing and forage for both wild and domestic animals. However, it also operates a multiple use program in which land use for recreation is of great importance. In fact, 236 sites have been

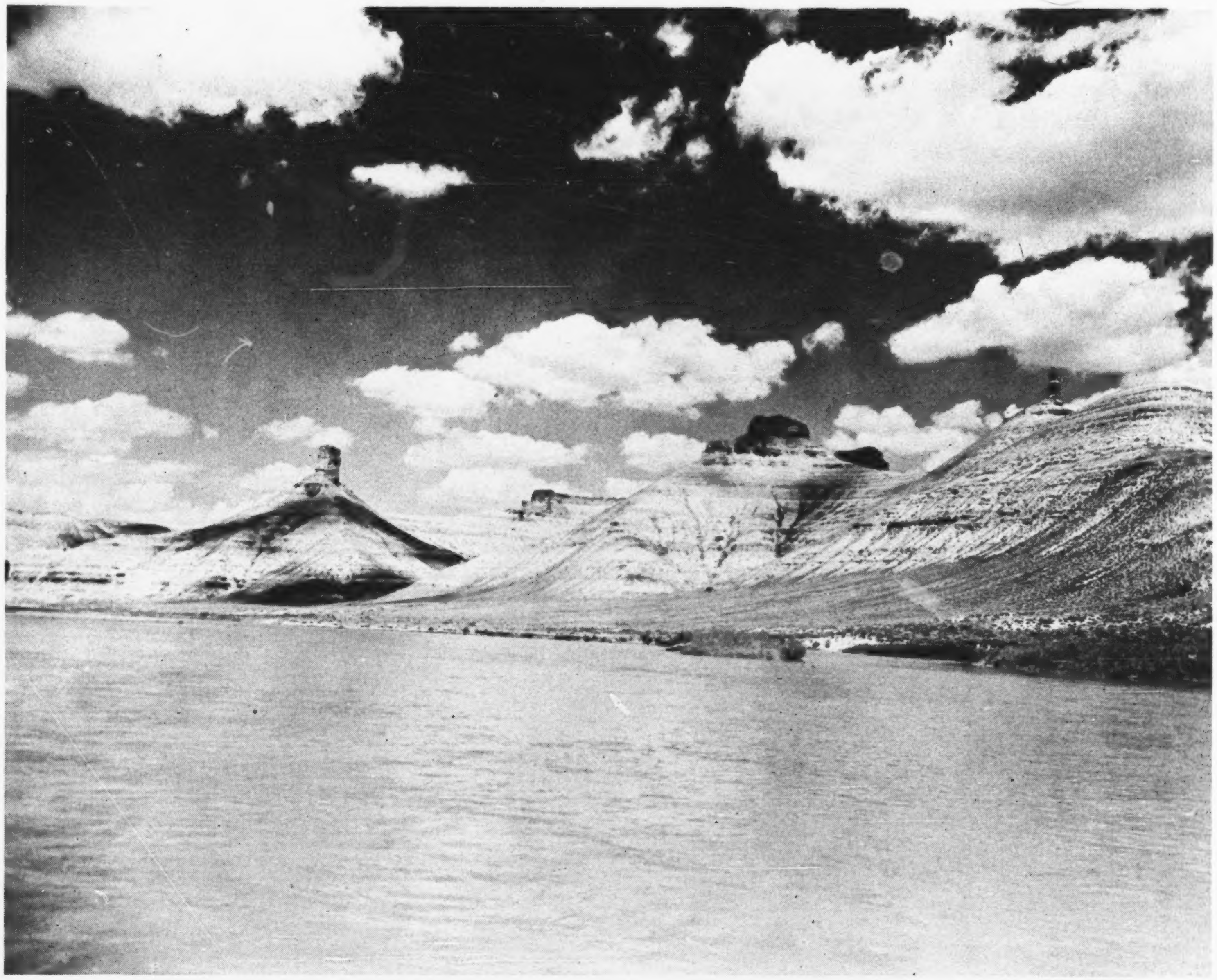

Fig. 42. Flaming Gorge National Recreation Area (Wyo. Travel Comm. photo).

inventoried for recreation uses on this public land. These include camping, road side rest stops, boat ramps, picnicking and scenic overlooks. Many of the proposed developments resulting from the inventory lie in areas of superb natural beauty, a reminder that not all of Wyoming's scenic grandeur and wildlife is included in the parks and forests, but that some lie on other public lands.

Unlike most other Federal agencies, the Bureau of Land Management may transfer federal lands under its jurisdiction to other divisions of government, state or local, for recreational uses. For example, Congress has provided the machinery whereby the title to a parcel of land may be transferred to the Wyoming Game and Fish Commission for use as a fishing access area, or for any other recreational use.

The Bureau has initiated and made great progress in another program which combines the historic with recreation. They have, with the cooperation of local historical societies, installed over 200 Oregon Trail Markers on federal public land, and have done much to mark and protect graves and other important historical features. The Sublette County Historical Society has been particularly active with the Bureau in installation of these markers, all of which are accessible and add so much to the total recreation values of an area.

The Bureau has made a specialty, in some areas, of developing horseback and hiking trail systems with recreation the primary purpose.

U. S. Department of Agriculture

U. S. Forest Service. The U. S. Forest Service long ago instituted a highly successful program of multiple use of forest lands throughout the nation including the 9.1 million acres of forest land it manages in Wyoming. The program encompasses the use of national forests for livestock range, watershed protection, mining, lumber and recreation. Recreational use is becoming more important because of rapidly increasing trends in outdoor activity. Many of the national forests in Wyoming have scenic attractions nearly equal to those of the national parks. There is hunting and fishing in all the national forests, numerous good campgrounds and thousands of miles of excellent horseback and hiking trails. These facilities are being expanded and improved each year. All of the state's 12 ski areas are in national forests.

Of significance in Wyoming is the limited use of U. S. Forest campgrounds because of a short season, especially in areas of high altitude. For example, a campground in the state park at Guernsey can be used at least two months longer than the U. S. Forest campground near Togwotee Pass at Brooks Lake.

Administration in General

Changes are made occasionally in the administration of the State Park System. For example, Alcova, a very attractive and stable reservoir state park was transferred in 1966 by the Old State Parks Commission to the Natrona County Parks Board for administration. Natrona County is leading among Wyoming's counties in its interest in recreation as a county activity and currently operates five improved campgrounds among its numerous other recreation activities.

Flaming Gorge and the Fontenelle Reservoir are administered by the National Park Service. The Park Service, however, plans to give Fontenelle Reservoir to the State as a park site when the dam becomes stabilized. The Bureau of Land Management does occasionally transfer land to other agencies where it can be combined with a recreational project already in operation, to improve or enlarge that project.

Other agencies are also actively engaged in the business of tourism, both State and Federal. The Wyoming Highway Department, in addition to building and maintaining state highways also maintains 80 rest stops along the main thoroughfares. Both the U. S. Fish and Wildlife Service and the U. S. Bureau of Reclamation own and manage lands on which outdoor recreation is important. However, in neither case is recreation considered a major objective.

Unique in vacation attractions is the winter elk herd on the National Elk Refuge operated by the U. S. Fish and Wildlife Service, Jackson Hole. Visitors are encouraged to ride hay sleds and actually watch the feeding of the elk.

Although the Bureau of Reclamation built, and for a time, managed the recreational uses of all the state's large reservoirs, most of them since have been turned over to state administering agencies. Kortes Reservoir of the North Platte River System and Pilot Butte of the Big Horn River System are still managed entirely by the Bureau, including recreational uses.

Summary

The Rocky Mountain area, including Wyoming, no longer enjoys only a summer tourist season. Winter travel is becoming more common and, with the opening of additional roads for winter use, great new areas can be made available for recreation—such as those in Yellowstone and other areas attractive to the winter sports enthusiasts. Because of this trend, Wyoming will see a new era of prosperity, especially if these new activities are considered along with those already in use. It is economically important to extend the tourist season; increased interest in winter sports and winter travel will accomplish this. The current movement to have Yellowstone National Park kept open for year-round travel will have important recreational and economic values for Wyoming.

However, a collection of detailed, accurate, inventory type information will be of primary importance to the future development and promotion of Wyoming's outdoor recreational resources. Comprehensive studies need to be made such as a complete origin and destination study, a demand study, and a study of all types of expenditures by the visitor in the state.[20] Present information, for example is very limited or entirely lacking concerning the value of revenue derived from boating or skiing activities.

Various State and Federal agencies and departments have administrative, advertising and development duties. Although lines of authority do not cross, areas of responsibility sometimes do. Therefore, as has been amazingly well demonstrated over the years, interdepartmental responsibility and cooperation are the key to success in realizing the full potential of Wyoming's recreational and scenic attractions.

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[20] In 1966 a demand study was authorized by the State Land and Water Conservation Commission (Consolidated into the Wyoming Recreation Commission by the 1967 Wyoming Legislature) in the amount of 76.1 thousand dollars under the title of "An Economic Analysis of the Demand for Outdoor Recreation in Wyoming." The study will attempt to: (1) Classify and inventory the existing supply of public and private outdoor recreation facilities in Wyoming; (2) to estimate the present use patterns and demand, by activities, for outdoor recreation in the state for residents and non-residents; (3) to project future demands for outdoor recreation, by activities, for a period of at least five years, for residents and non-residents; (4) to identify critical research problems in the field of outdoor recreation; and (5) to develop a coordinated long-range program of outdoor recreation research.

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Human Resources

DWIGHT M. BLOOD[21]

The term *human resources,* simply stated, is another term for people. However, there is a conceptual difference between the two labels: the term resource involves the concept of an element of production which can be converted into wealth or into assets representing wealth. Wealth serves as an imprecise but useful proxy for welfare. Thus, the inventory of people in Wyoming constitutes the pool of human resources available for generating economic and social development in the State.

The principal motive in examining and understanding human resources stems from the concept that the basic characteristics of people can be deliberately and voluntarily altered over time. Upward shifts in education, skill, and health levels are likely to result in upward shifts in aspiration and achievement levels, and thus result in higher levels of human welfare.

An examination of the field of human resources involves: (1) development of a framework of concepts within which human resources in Wyoming can be examined; (2) description of some of the characteristics of Wyoming people and of the measurement problems associated with the evaluation of these characteristics; and (3) determination of the magnitude of some of the public programs for the conservation and development of human resources in the State.

The concept of people as a pool of human resources has undergone vast change in recent years and is not completely understood even today. Although economists have traditionally linked management and labor with land and capital as the classical factors of production, it has been only recently that the role of human capital has become the focus of intensive consideration (Becker, 1964; Ginzberg, 1966; Schultz, 1961).

As economists have developed measures of economic growth, they have attempted to assign the causes of growth to traditional categories of physical capital. There is a remainder, however, that can logically be accounted for only by the contribution of human capital.

There now exists a growing awareness that investments can be made in human, as well as physical resources. The penalties and growing social costs of underinvestment in human resources have become increasingly apparent.

Investments in human capital, however, are limited by severe competition for limited public funds. Moreover, adequate objective information about the costs and benefits of alternative programs often is not available to public decision-makers. Ideally, the optimum level of spending on human resources under a situation where there is not enough money to take care of all demands exists when the last dollar spent on any one program returns the same benefits as the last dollar spent on any other program. Thus, for example, the last dollar spent on education returns the same benefits as the last dollar spent on highway safety. Yet sufficient public funds may not be available to develop either highway safety or education to the level that would be optimum if unlimited money was available.

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Objections are sometimes heard about the inclusion and consideration of people in the mechanistic, materialistic framework of human resources. Yet the stock of human resources at any given time (as measured in terms of existing skills, education, and the other characteristics) constitutes a limit on short-run economic growth. As time passes, the range of possible growth levels is enlarged as human resources renew and regenerate and acquire higher levels of education and competence.

Investments in human resources may take at least four basic forms (Socknat, 1966):

1. *Conservation of human resources.* Such programs maintain and improve mental and physical well-being. Examples are programs for industrial and highway safety; abatement of water and air pollution; hospitals; employment security and workmen's compensation.
2. *Utilization of human resources.* Programs in this category include those designed to place people in jobs where they can be productive and earn a living, such as employment and counselling services.
3. *Development of human resources.* Investments in human resource development involve those programs aimed at upward shifts in the skill and performance levels of the population. Examples include investment in education at all levels, libraries, and communications media.
4. *Development of the quality of environment.* The aesthetic qualities of environment that are necessary to make cities, towns, and the countryside clean and pleasant places to live must be identified. The costs and benefits of investments (or lack of investments) designed to enhance these qualities must be clearly understood.

THE STRUCTURE AND CHARACTERISTICS OF WYOMING'S HUMAN RESOURCES

The basic problem in evaluating human resources is that a detailed inventory of people and their characteristics is undertaken only once each decade in the U. S. Census of Population. The principal value of census data is that they serve as benchmarks. The difficulty with census data is that they are out of date as soon as they are tabulated because of high mobility levels and the rapidly changing characteristics of the population. The Division of Business and Economic Research receives numerous requests for recent Wyoming demographic data; the need for a quinquennial (every five years) census is becoming increasingly apparent.

The only present alternative to more frequent census counts is to make estimates of the population based on symptomatic evidence of indicators of population change such as school enrollment and meter connections. While such estimates may carry respectable levels of reliability in large geographic areas, the error is likely to increase as the geographic unit for which the estimate is made decreases. Such estimates do not involve the presumed thoroughness or finality of the census count; therefore, the conclusion is frequently drawn that such estimates do not possess the validity of the census count.[22] Hence, there is a need not only for more frequent census data but for more research on optimum methods of intercensal estimates so the validity of the final estimate may be more apparent. However, even successive census benchmarks may obscure significant intercensal population fluctuations that can be revealed only by various estimation procedures.

Data on the total population provide an outer limit for estimating requirements for many major public goods and services. There were about 329,000 people in Wyoming in 1966, a decline from the 1960 estimate of 330,066. Wyoming's population grew from 194,402 in 1920 to 225,565 in 1930, 250,742 in 1940, and to 290,529 in 1950 (U. S. Bureau of the Census 1960 and 1966a). The rates of population change for Wyoming and the U. S. since 1920 are shown in Fig. 43.

Absolute numbers of people are an important clue to investment requirements for human resources. Yet the composition, characteristics, and migration of the population provide equally important clues for human resource requirements and programs.

Population growth in Wyoming equaled or exceeded the national rate of increase from 1920 until 1950. Since 1950 the rate of population increase in Wyoming has slowed down; and since 1960 the population of the State has probably declined slightly, according to the most reliable

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[22] At the same time, it should be noted that even the decennial censuses of population are not precisely accurate, since there are persons who are overlooked (some travelers, skid-row inhabitants, etc.); hence, even the census data are published with an explanation of the probable error. Census figures on incomes, places of residence, and similar categories, are based on samples of households, and are thus only estimates.

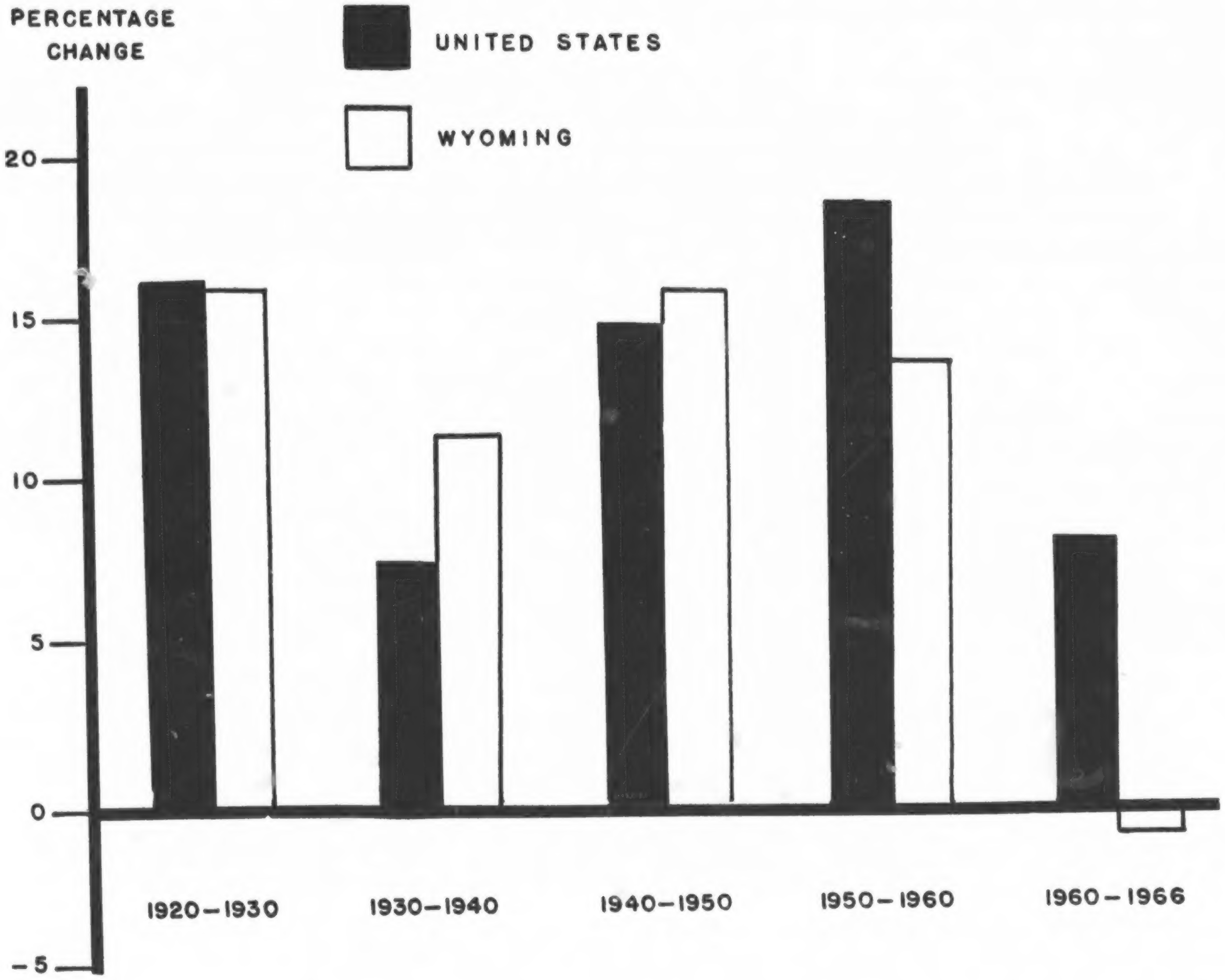

Fig. 43. Rates of population growth, United States and Wyoming, by specified time intervals, 1920-1966 (U. S. Burr. Census, 1960 and 1966a).

estimates available.[23] These observations are usually met with mixed reactions. Many people living in Wyoming are pleased by the sparse population and uncrowded living conditions and feel that a low rate of population growth is the main reason they stay here. Certainly the planning and operation of schools, hospitals, and other public facilities can be carried out in a much more orderly manner in Wyoming than in states confronted with pressures of rapid population increases. Yet, population growth is a desirable ingredient of economic growth, and an expanding economy requires a growing pool of skilled labor and professional and managerial manpower.

It is estimated that 20 percent of the people in the United States changed residence in the period March, 1964, to March, 1965 (U. S. Bureau of the Census, 1966a). Wyoming people are no exception to national trends. For example, native-born Wyomingites seem to have a greater inclination to move from their state of birth than do people in other states (Larson, 1965).

The decision to move is ordinarily expensive and constitutes an investment in human resources. Migration patterns represent shifts in the geographic distribution of economic opportunity. Since young people can expect a longer payoff period in which to recoup their investment, they are more likely to move (Schultz, 1961).

The net migration of Wyoming population[24] from 1870 until 1965 is shown in Fig. 44. More people moved into Wyoming than moved out until the 1930's. Beginning with the decade of the forties, the rate of outmigration from Wyo-

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[23] The most recent population estimates for Wyoming and all states and recent information about national population characteristics can be obtained by subscribing to the Current Population Reports series of the Bureau of Census, especially to the following series:

Population Estimates, Series P-25, U. S. Government Printing Office, Washington, D. C.

Population Characteristics, Series P-20, U. S. Government Printing Office, Washington, D. C.

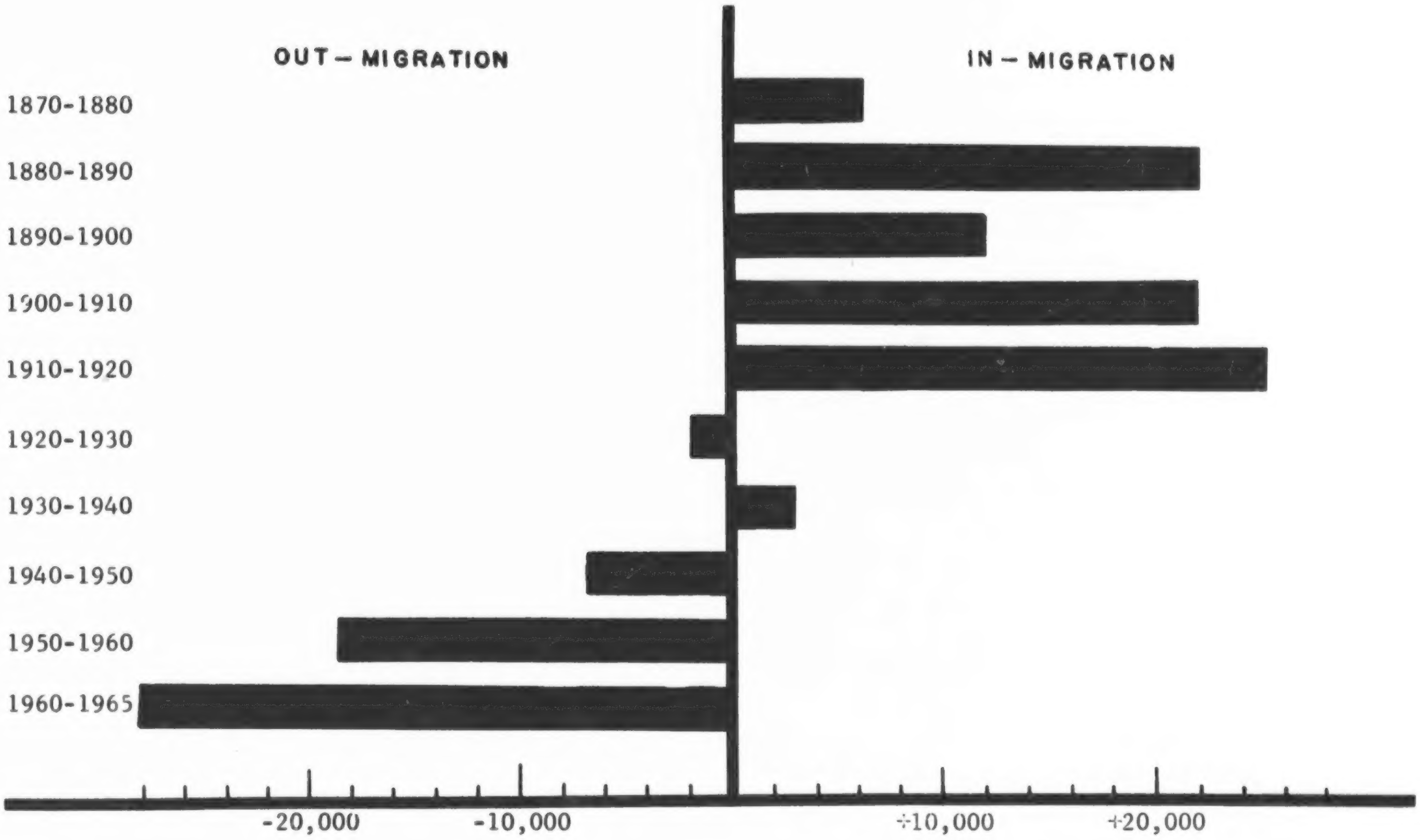

Fig. 44. Net migration of the Wyoming population, by specified time intervals, in thousands of people, 1870-1880 to 1960-65 (Hope and Thomas, 1964; U. S. Bur. Census, 1962 and 1966a).

ming accelerated. For the first five years of the current decade, a 40 percent higher net outmigration was registered for the entire previous decade. The excess of births over deaths and over outmigration accounted for a net population increase in Wyoming until 1960, but accelerated outmigration since 1960 has probably resulted in a net population loss in the past six years.

It must be emphasized that net outmigration is common to many states that have had to make a transition from a traditional agricultural and extractive economic base to a more diversified industrial base. Wyoming is not unique in this respect, and given the magnitude of the economic transition in the State, it might be concluded that outmigration and population change have been a natural and expected outgrowth of necessary shifts in the Wyoming economy. There is certainly no immutable law that says that the Wyoming economy must grow at national growth rates; indeed, with the unique agricultural-industrial mix the State has, it is unlikely that it will do so. At the same time, it is equally true that expansion in the State's labor force in significant numbers is not likely to come about until a significant shift in industrial structure takes place.

At the turn of the century, nearly half of the Wyoming labor force was employed in agriculture and mining (Kuznets, 1960). By 1960, only one-fifth of all employed persons in Wyoming worked in these two industries (U. S. Department of Commerce, Bureau of the Census, 1960). Less than 8 percent of Wyoming's nonagricultural workers were employed in manufacturing by 1965, while at the national level nearly 30 percent were employed in manufacturing (U.S. Bureau of the Census, 1966b). In fact, there are fewer workers in manufacturing in Wyoming now than there were in 1960 (U.S. Department of Labor, Bureau of Labor Statistics, 1965). This decline has been registered despite the fact that manufacturing nationally has registered a growth rate as measured by value added of nearly 5 percent in comparing the period from 1957-60 with the period 1960-64 (U. S. Department of Commerce, Bureau of the Census, 1966c). In comparison with national percentage distributions by industry, relatively more Wyoming people work at jobs in mining, transportation, contract construction, and government than do people in the rest of the nation. Many sectors of the Wyoming economy are highly seasonal in nature. About 27 percent of

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[24] Net migration is the difference between the number of people moving into the State and the number moving out. A state can have a net loss in migration and still have a population increase due to the excess of births over deaths.

Wyoming's nonagricultural labor force in 1965 was employed by government—state, federal, and local—making it the largest employer in the State. Wyoming's unique employment distribution among industries suggests that the State's industrial structure has had an important impact on the number and characteristics of Wyoming's human resources.

A further clue to the characteristics of Wyoming's human resources is given in Fig. 45, which shows the relative changes since 1960 in the age distribution of the Wyoming population.

The shift in age distribution since 1960 demonstrates a decline in the productive population category in the 18-44 bracket, with an accompanying decline in the proportion of children under 5 years of age. If these estimates are correct, they indicate that an increasing proportion of young jobholders with young children have been moving out of the State, leaving an increased share of the population in the 45-64 category with children 5-17 years of age, and an important 12 percent increase in the share of the population over the age of 65. Between 1950 and 1960, about 43 percent of the estimated 19,671 outmigrants from Wyoming were in the 20-44 age bracket (U. S. Department of Agriculture, Economic Research Service, 1965). Relative increases in the size of the dependent population, and relative decreases in the size of the productive population suggest, among other things, that requirements for hospitals and schools will increase and that it will become more difficult for the remaining population to pay for these facilities.

There are many additional characteristics of the Wyoming population that are significant for human resources conservation, development, and utilization. One of these characteristics is population density. There are less than three and one-half people per square mile in Wyoming, yet one-third of the population lives in Laramie and Natrona Counties, and half lives in the four counties with a population of greater than 20,000: Laramie, Natrona, Fremont, and Albany. The sparseness of the Wyoming population results in relatively high per capita expenditures for public goods and services since schools, roads, hospitals, and other facilities must be maintained at acceptable levels even in the most remote areas of the State. Thus, counties with a declining population may not necessarily experience a decline in cost of government, because of the fixed cost of maintaining the service or facility and because of rapid increases in the cost of services relative to changes in other costs.

Another important shift in Wyoming's human resources, as in the national picture, is the continued migration of people from farms to towns and cities. At the turn of the century, only 29 percent of Wyoming's population was urban; by 1960, 57 percent were living in urban areas (U. S. Bureau of the Census, 1961), while nationally 70 percent of the population had moved to urban areas by 1960 (U. S. Bureau of the Census,

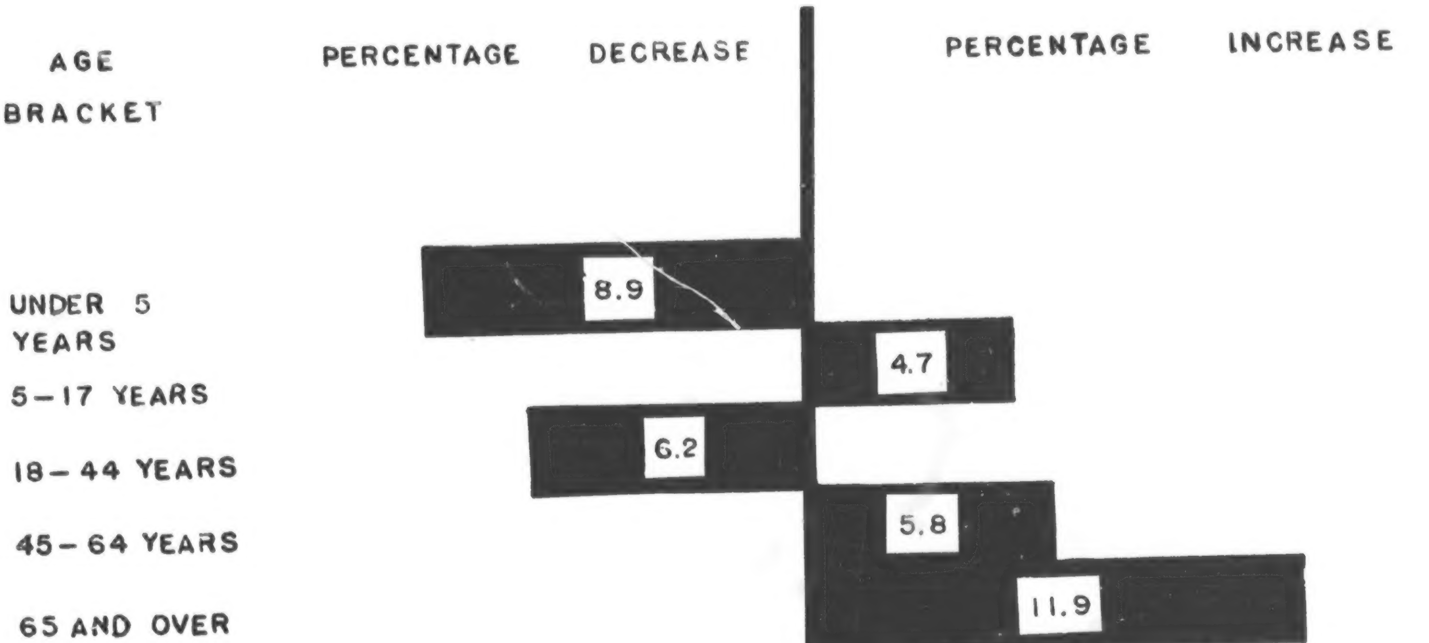

Fig. 45. Estimated percentage changes in Wyoming population, by age bracket, 1960-1965 (U. S. Bur. Census, 1966b).

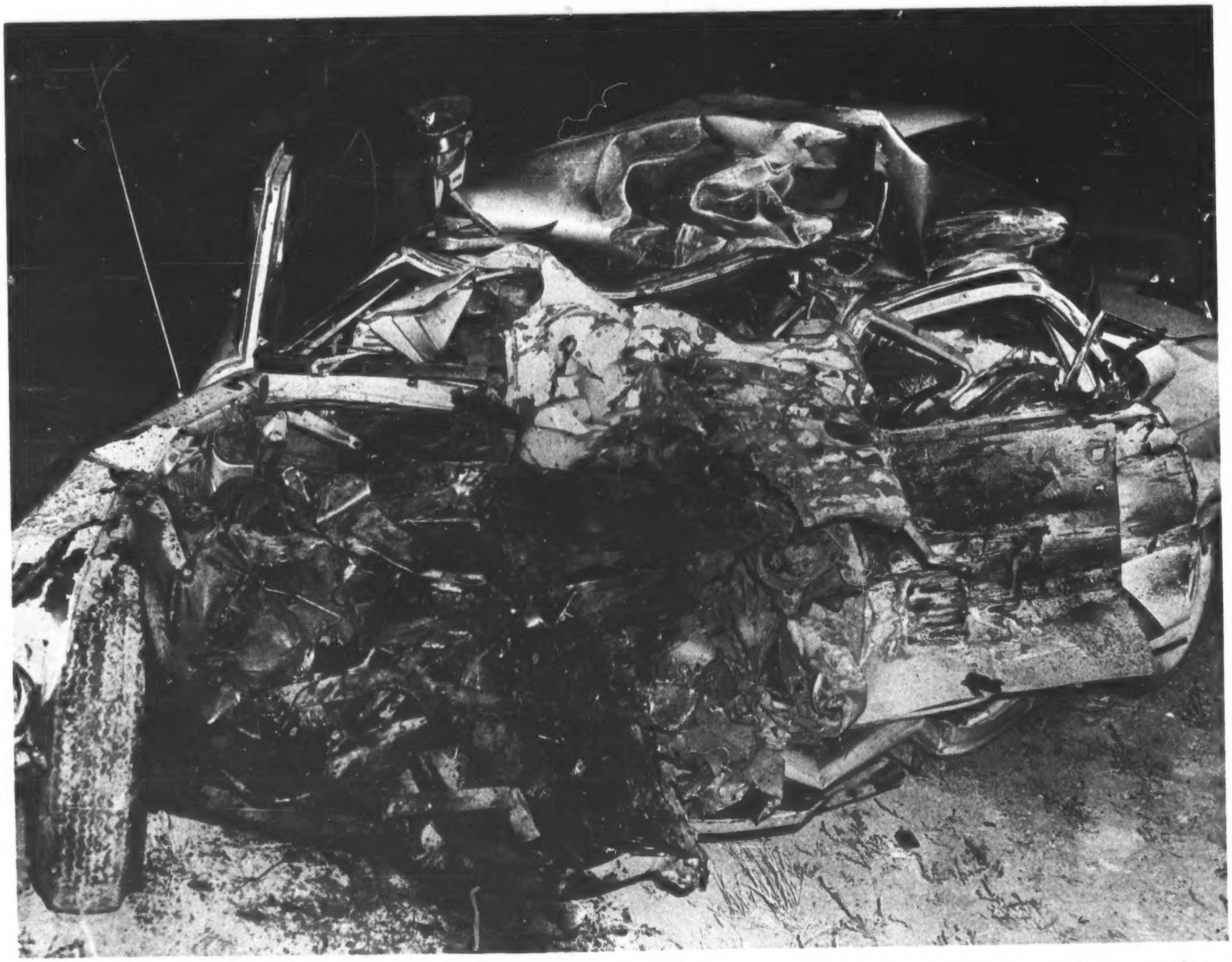

Fig. 46. Wyoming's highway accident record is quite high when compared to the rest of the nation (Photo by J. Nelson).

1966b). Of the 43 percent living in rural areas in Wyoming in 1960, only 13 percent were classified as rural farm, while 30 percent were classified as rural nonfarm. Less than half of the people in Wyoming (44 percent) were living in their state of birth (U. S. Bureau of the Census, 1961).

Only two-fifths of Wyoming people in 1960 were living in the same house they occupied in 1955, while 28 percent had lived elsewhere in the same county, 9 percent had lived elsewhere in Wyoming outside the county, and one-fifth had lived elsewhere in the United States (U. S. Bureau of the Census, 1961).

Nearly 15 percent of Wyoming families had incomes of $10,000 and over in 1960 (U. S. Bureau of the Census, 1961), which approximated the estimate of 14.3 percent of families in this category nationally (U. S. Bureau of the Census, 1966b). At the other end of the income distribution, 21.7 percent of all families in the nation had incomes of less than $3,000 in 1960, while 16.5 percent of Wyoming families were in this category (U. S. Bureau of the Census, 1966). Per capita incomes have continued to increase in absolute terms in Wyoming but have declined in growth rates relative to national increases in per capita income (U. S. Department of Commerce, Office of Business Economics, 1966).

Of persons 25 years of age and over in 1960, 9 percent had 4 or more years of college, 12 percent had some college, 31 percent had graduated from high school, and 48 percent had less than a high school education (U. S. Bureau of the Census, 1961). The median number of school years completed was 12.1 years.

CONSERVATION OF HUMAN RESOURCES

Highway safety

In a comprehensive analysis of traffic accident costs and the effectiveness of highway safety expenditures in Wyoming, Professor Raymond W. Hooker has concluded that the Wyoming highway accident record is deteriorating relative to the rest of the country; that is, it is becoming more dangerous to drive in Wyoming while it is becoming safer to drive in the rest of the country (Fig. 46) (Hooker, 1966).

Since 1963, traffic death rates have been substantially higher for Wyoming than for the nation. At the same time, Professor Hooker has found that accident costs have risen more rapidly in Wyoming than has the average of such costs for all states. His study concludes that substantial improvements are required in Wyoming's highway safety programs if the State is to match the progress of other states. An additional dollar spent on the Wyoming Highway Patrol, for example, was found to reduce highway accident costs more than $12—a return of more than 1,000 percent a year during the study period. With increasing pressures on the State at the federal level to inaugurate programs to improve safety on the highways (see, e.g., New York Times, 1966), Wyoming should consider seriously its safety record and the high potential returns, in minimizing human suffering and aggrievement, that could result from increased investment in highway safety programs.

Industrial safety

A recent study of on-the-job industrial deaths and injuries in Wyoming by Professor Edmond L. Escolas (1966) has shown that: (1) there has been no definite upward trend in fatal industrial accidents either in the aggregate or for any single industrial classification; (2) nonfatal on-the-job accidents have generally increased over the past eleven years (Fig. 47). Professor Escolas concludes Wyoming's industrial accident record is excessively high, based on objective standards of comparison. He also notes Wyoming is one of the few states without a factory inspection law to require Wyoming employers to provide safe, healthy places in which to work.[25]

Water and air pollution

Wyoming is characterized as a land of wide-open spaces and clear blue skies. Yet research is urgently needed to determine the quantity of pollutants entering the air and water of the State (Fig. 48). The impact of petro-chemicals, sewage lagoons and other waste disposal facilities, discharge of industrial wastes, cement manufacture, city dumps, and other processes and facilities must be identified. The economic costs and benefits to individuals, companies, and to the collective citizenry of the State of alternative levels of pollution control must be estimated and clearly understood.

The 1967 Wyoming Legislature passed the Wyoming Air Quality Act (Session Laws of Wyoming, 1967, Ch. 186) in recognition of the importance of air pollution problems.

Consideration of effective pollution controls is essential if the State is to preserve, and, in some cases, recapture the quality of its water and air which serves as an important attraction and resource both to the people who live here and to those vast numbers who visit Wyoming.

Health and hospitals[26]

The Division of Vital Statistics of the Wyoming Department of Public Health reports that accidents were the leading cause of death in the age group 1 to 35 in 1965 (Wyoming Department of Public Health, Division of Vital Statistics, 1965), and that accidents ranked third among causes of death for all Wyoming residents (Wyoming Department of Public Health, Division of Vital Statistics, 1965). The accidental death rate in 1964 was 109.7 per 100,000 population; it was 103.5 in 1965, nearly double the national rate of 55.1. Similarly, the motor vehicle death rate of 54.1 was more than double the national rate of 25.2 (Wyoming Department of Public Health, Division of Vital Statistics, 1965).

Births in Wyoming declined from 8,454 in 1961 to 6,412 in 1965, accompanied by a decline in the birth rate from 25.2 to 18.9. The Wyoming birth rate has reached its lowest level since 1937, reflecting the national trend, and has declined sharply from the all-time high rate of 29.4 registered in 1953 (Wyoming Department of Public Health, Division of Vital Statistics, 1965). These findings have important implications for projecting public school requirements.

The crude death rate for Wyoming of 8.2 is somewhat below the national rate of 9.4. Heart disease and malignant neoplasms (cancer) are the leading causes of death for people over the age of 35 (Wyoming Department of Public Health, Division of Vital Statistics, 1965). With

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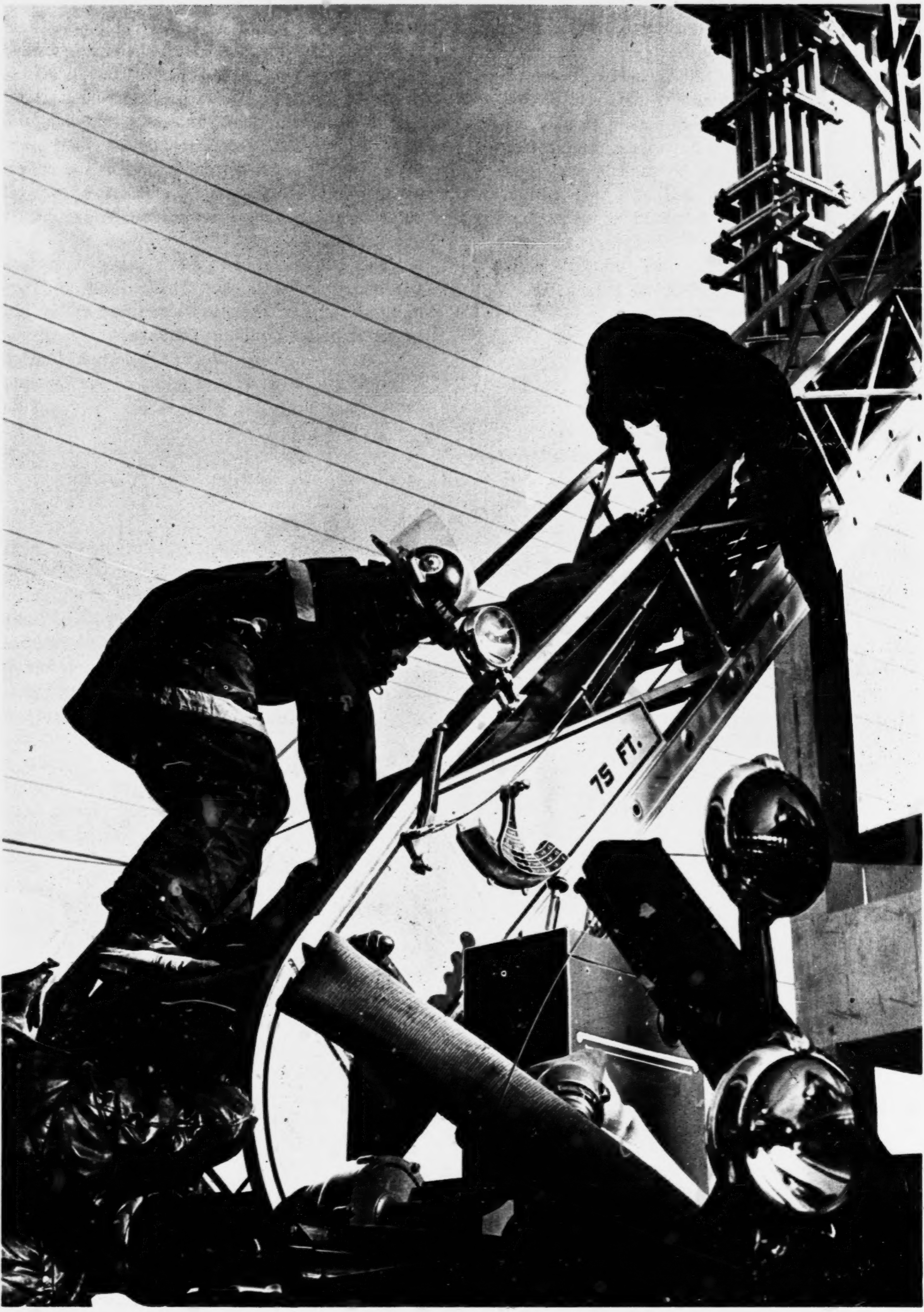
[25] For a review of Wyoming's workmen's compensation program, see Edmund L. Escolas, "Wyoming's Workmen's Compensation, 1915-1960," *Wyoming Trade Winds*, Division of Business and Economic Research, University of Wyoming, Vol. 4, No. 10, December 1961, pp. 8-12. See also: Ray Stoddard, *A Proposed Revision of the Wyoming Workmen's Compensation Law*, Wyoming Legislative Council, Research Report No. 63-4, Cheyenne, Wyoming, 1962. Wyoming Legislative Council, *A Proposed Revision of the Wyoming Unemployment Compensation Law*, Cheyenne, Wyoming, 1962.

[26] The rates expressed here are all per 100,000 population.



(3)

Fig. 47. Industrial accident at a Wyoming construction site.

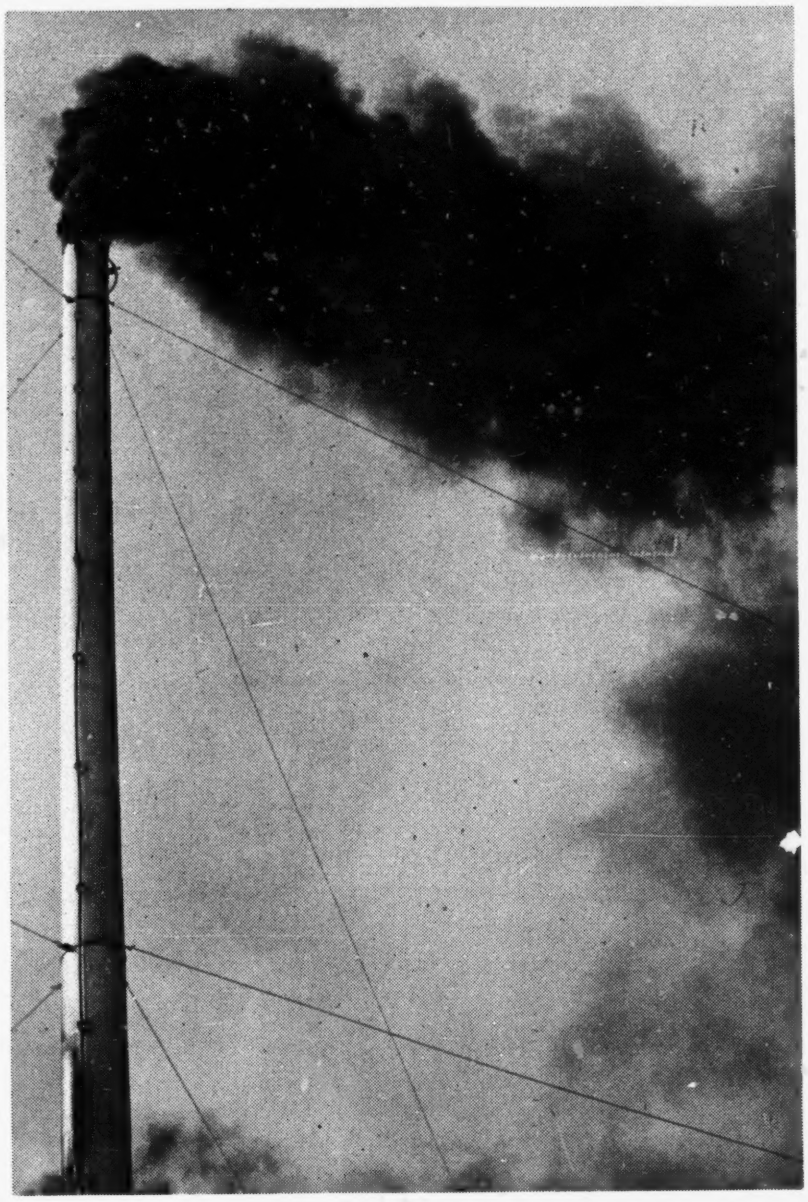


Fig. 48. Air pollution is rapidly becoming a problem in several areas of Wyoming.

the relative increase in Wyoming population over the age of 65, the character of required health services will also change.

Wyoming's total per capita expenditures on health and hospitals in 1964-65, including expenditures on capital outlay, were estimated at $42.93, or considerably above the national average of $27.66 (U. S. Department of Commerce, Bureau of the Census, 1966b). This comparison once again may indicate the relatively high costs of maintaining adequate facilities for a widely scattered population. High per capita costs do not necessarily mean uniformly high standards of quality for medical and health facilities. A determination of standards and levels of performance for Wyoming's health facilities would require a comprehensive research project.

Utilization of Human Resources

Job seekers require information on the availability, types, and locations of employment. They also require information on their own capabilities to enter alternative fields of employment. Without adequate job information, human resources may not be utilized at optimum levels.

Through the Employment Service Division of the Wyoming Employment Security Commission, 21,900 job placements were made in 1965, of which 7,555 placements were made with farm and ranch employers (The Employment Security Commission, 1965). New programs have been geared to employment of youth and service to handicapped persons. The Employment Security Commission has also attempted to raise the professional competence of its employment service counselors by participating in in-service training programs.

Research is needed on the adequacy and effectiveness of existing employment services in meeting the informational requirements of all classes of job seekers. The requirements for adequate counseling facilities for people in all age brackets must also be identified.

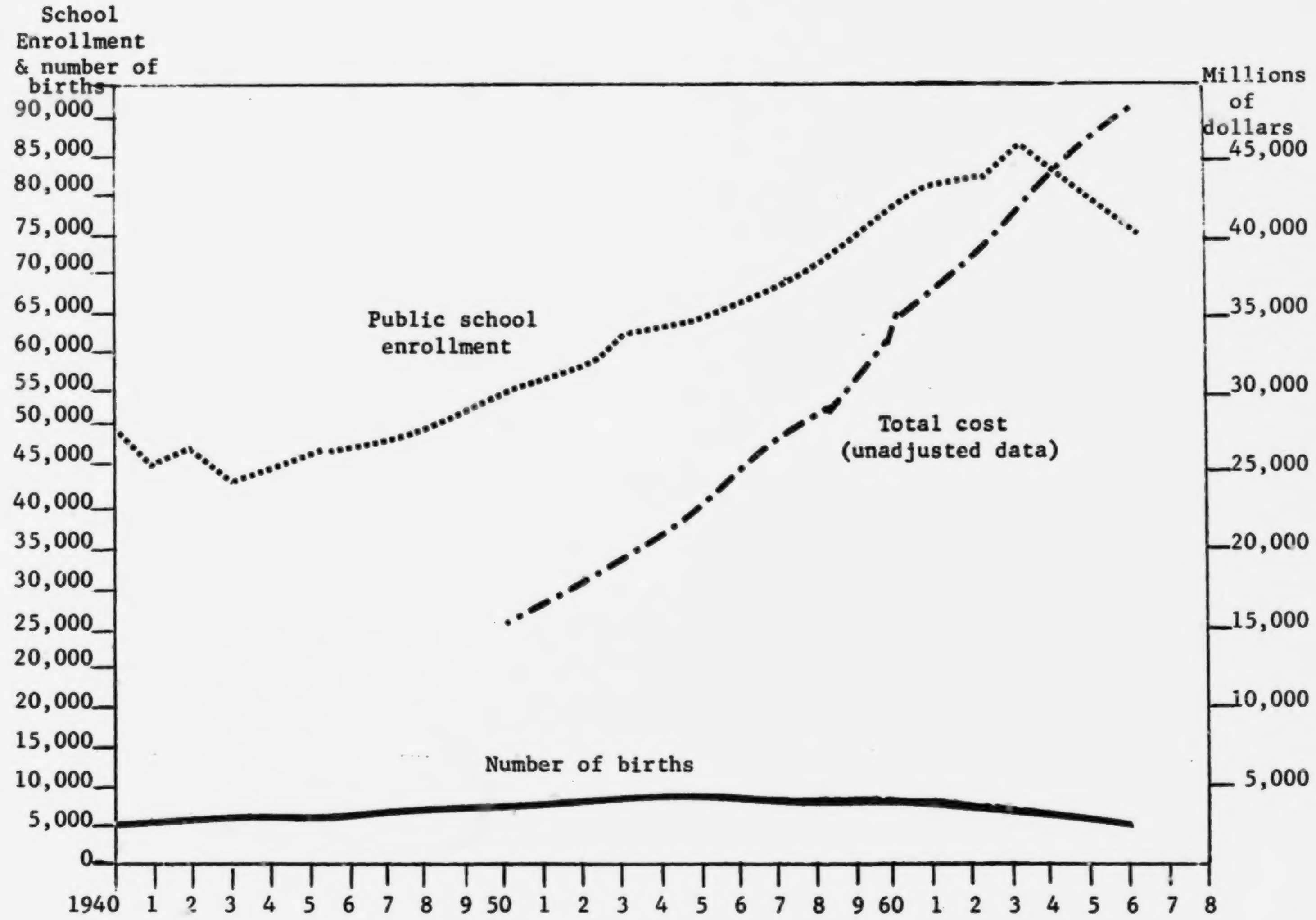


Fig. 49. Wyoming public school enrollment, total cost of public schools and number of births, 1940-1966 (Wyo. Dept. of Educ., 1961, 1965a, and unpubl.; Wyo. Dept. of Public Health, 1966).

DEVELOPMENT OF HUMAN RESOURCES

Public elementary and secondary education

Education is the principal means of developing human capital. The ability to adjust to change and to live productive useful lives is facilitated by education. Income and education are so closely related that one magnitude can be estimated accurately for groups of people if information on the other is available.

Yet education also equips people with skills they may not be able to market in their home areas. In localities with slowly growing or declining populations, economic opportunities for those trained for professions and for highly skilled jobs may not be sufficiently attractive to hold people in the region.

Public school enrollment, number of births, and total public school costs are shown in Fig. 49. Although the dollar costs would not increase as sharply as they do in the graph if they were deflated to allow for price level changes, the graph nonetheless depicts the increase in education costs in the face of declining school enrollment.

Total taxable valuation in Wyoming increased only 1.7 percent between 1965 and 1966 (Twenty-Fourth Biennial Report of the Wyoming State Board of Equalization, 1965-66), while estimated total school expenditures increased nearly 7 percent (Wyoming State Department of Education, Division of Research and Statistical Services, 1965b) in the same period despite a statewide decline in school enrollment of over 1,300 pupils (Wyoming State Department of Education, Division of Research and Statistical Services, unpublished data). Since there exists a high fixed cost to the maintenance of minimum levels of public services in widely scattered geographic areas, pressures for improvement and expansion of public services create difficult problems for policy makers.

Through widespread citizen support, Wyoming has made vast strides in improving public education. Consolidation of schools and school districts, development and continual re-evaluation of the Wyoming School Foundation Program, development of programs for the deaf and physically handicapped, development of new programs in vocational education—all of these and many other programs have helped to ensure that Wyoming children are not penalized by the chance occurrence of their place of birth[27].

Wyoming spent $146 per capita on local schools during the 1964-65 school year, well above the national average of $115 (U. S. Department of Commerce, Bureau of the Census, 1966b). As in the case of per capita expenditures on health and hospitals, however, per capita expenditures on education are influenced not only by attempts to attain equality education, but also by the high cost of maintaining facilities for a sparsely settled population.

Higher Education[28]

The growth of higher education has had a direct bearing on rising income levels. The economic effects of higher education are not limited, however, to the improved economic status of trained students. The growth of education facilities has had a direct economic impact on the communities in which they are located, not only through increased payrolls and increased demand for goods and services, but also through furnishing a pool of skilled manpower available for consultation on community problems. University faculty and university programs have become extensively involved in the critical problems of both the public and private sectors. University programs are reaching and benefiting a wider cross-section of the population. The prototype of the University as a place where 18-22 year-olds go for anywhere from one semester to four years is vanishing as people in all segments of the population are seeking to attain new skills and levels of competence. Housewives whose children are raised; retired persons; the physically handicapped; victims of technological change; or square pegs who have been in round holes—all of these people are finding increasing opportunities and challenges in continuing their education. Proper planning and development of post high school education will help to ensure that Wyoming's human resources can be utilized effectively through adaptation of skills to changing labor force demands.

Total university and college enrollment has more than doubled in Wyoming institutions of higher education in the past 10 years, as well as at the University of Wyoming itself. The percentage of Wyoming youth 18 to 21 years of age attending Wyoming colleges has increased from 6.4 percent in 1940 to 22.4 percent in 1965. Approximately 20 percent of Wyoming high school graduates enroll at the University of Wyoming, and another 28 percent enroll at Wyoming community colleges (O'Dell and Thompson, no date). Yet, in 1963 it was estimated that one-third of all state residents attending college were attending in other states while nearly 32 percent of all students attending the University of Wyoming in 1964-65 were from out of state (U. S. Department of Health, Education and Welfare, 1963).

The role of the University of Wyoming and of Wyoming's five existing Junior Colleges (Casper, Powell, Sheridan, Torrington, Rock Springs), and a sixth to be opened to students in 1968 (Riverton), will clearly continue to expand in the direction of constructive involvement in community affairs and in the economic and social growth and development of the State. Economic growth, in turn, will enable more of Wyoming's capable, well educated, young people to remain in the State and to establish their homes and families here. The State should not overlook the potential also for retaining out-of-state students in Wyoming once they have been educated here. These students could well represent Wyoming's most significant import.

DEVELOPMENT OF WYOMING'S ENVIRONMENT

People are becoming increasingly aware that haphazard, uncontrolled development results in more inequities and infringements on human rights and welfare than the initial controls themselves would have imposed. The benefits of planning in Wyoming are becoming increasingly apparent as the role of planning is becoming better understood. A plan, traditionally, has implied bureaucratic control and regimentation. Yet today, with the necessity of planning in order to cope with the sheer complexities of economic and social change, people are developing an appreciation of a plan as a flexible blueprint for orderly development. A viable plan never remains fixed, but changes with new conditions and circumstances.

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[27] For the most comprehensive recent scholarly analysis of school finances in Wyoming, see: (1) Walter C. Reusser and Loren Aldrich, *The Wyoming School Foundation Program, Vol. I, A Proposed Revision of the Cost Formula,* Wyoming Legislative Council, Research Report No. 63-7, Cheyenne, Wyo., 1962. (2) Allyn O. Lockner, *The Wyoming School Foundation Program, Vol. II, A Proposed Revision of Property Tax Administration,* Wyoming Legislative Council, Research Report No. 63-7, Cheyenne, Wyo., 1962. (3) Allyn O. Lockner, *The Wyoming School Foundation Program, Vol. III, The Common School Land Income Fund: A Proposed Classification and Multiple Use of State Lands,* Wyoming Legislative Council, Research Report No. 63-7, Cheyenne, Wyo., 1962.

[28] For a comprehensive compilation of basic data on higher education in Wyoming, see: Earl D. O'Dell and John Thompson, *Post High School Educational Needs in Wyoming,* Chapter IV, "Problems of Higher Education in Wyoming," University of Wyoming, Laramie, to be released.

Wyoming has not scratched the surface on planning. There is not now employed directly by any units of state or local government a qualified, registered professional planner although attempts have been made and are now being made to remedy this situation. The institutions of higher education are involved only in a minor way in planning either in terms of teaching or of research.

Several communities have undertaken community planning studies, most of them emphasizing land use patterns in towns and cities. Most of the limited economic base studies completed earlier by the Division of Business and Economic Research are now more than ten years out of date. Many of the existing studies have suffered in the investigation stage because of a lack of current knowledge about the state, and in the implementation phase because of the lack of a well-organized, well-coordinated set of planning machinery in the State.

Virtually no state-wide planning has been done. There have been no reliable economic forecasts or state-wide economic base studies to serve as an over-all framework for future planning.

The quality of the environment within which Wyoming people will live, and the ability of the State to attract and retain its residents, will be influenced heavily by the degree to which Wyoming communities develop and implement organized, coordinated plans for orderly growth, change, and development. These plans will not be easy or cheap to develop, and must come to grips with such controversial and emotional problems as zoning, sanitation, and pollution control; realistic approaches to meeting long-run financial requirements must be developed. Change costs money, and money for public goods and services is scarce. Yet people expect adequate streets, sewers, parks, police and fire protection, schools, and the like, and they take into account the availability and relative quality of such facilities among various communities in their decisions to move.

Fortunately, many, and perhaps most, Wyoming communities have made great strides in development of attractive, well-planned cities and towns. But such development has been facilitated in many cases by a relatively slow growth in population. If Wyoming embarks on a sustained and rapid growth rate in the immediate decade ahead, as the State begins in earnest to develop the full potential of its resources for outdoor recreation; as industrial growth and investment in plant and equipment continues; and as major shifts in the relative economic importance of traditional economic sectors in Wyoming take place—then one of the clearest needs Wyoming has is to develop orderly, flexible plans for adaptation to change for communities and for the State.

IMPLICATIONS

The preceding discussion suggests the question: Are the human resources of Wyoming victims of irrevocable shocks of economic and social change imposed on the State from the outside as well as from within, or do they possess an element of control over what is happening? The answer is a qualified yes to both parts of this question.

Increased levels of education have resulted in massive contributions of human capital to economic growth. The resulting increases in levels of population mobility have resulted in huge urban concentrations of people who have responded to economic opportunities available in the cities. Increasing upward shifts in technology and shifts in consumer tastes have resulted in changes in economic structure and in the demand for people with specialized skills. People with good jobs and high levels of skills have oftentimes been stranded by economic change and left jobless. Economic change is very impersonal; it does not necessarily reward those who have worked hardest or those who have the best skills. Wyoming has been affected by, and has had an impact on, all of these changes.

Thus, a profile of some important characteristics of Wyoming people shows that the State is experiencing a declining rate of population growth along with other states having heavy dependence on agricultural and extractive industries. People have decided to move out of the Midwest, Great Plains, and upper Rocky Mountain areas either to the periphery of the country or adjacent to the periphery to states such as California, Arizona, Nevada, Texas, Florida, New York, Connecticut, Maryland, and Virginia. Outmigration has been heaviest in the productive brackets of the labor force, resulting in relative increases in the dependent population. Since migration rates are barometers of regional shifts in economic opportunity and in preference patterns for residential location, important questions emerge concerning the ability of the State to hold its young, educated people. It may well be that Wyoming's most important export is not the wealth extracted from the earth but the well-educated, skilled young people with capacity and training for leadership, who leave the State in search of jobs and salaries to match the skills they have acquired.

Yet to assume the State can do nothing to respond constructively to the forces imposed on it is surely a defeatist attitude. One mistake most frequently made is to assume that money is necessary to implement change. Money is important, but much can be done in evaluating the effectiveness and contribution of some of the State's time-worn institutional arrangements for doing things. The effectiveness of citizen participation in human resource programs has been forcefully demonstrated, particularly in implementing changes in the educational system and in its system of financial support. The success of these programs hinged very largely on the action and support of an informed public.

Surely the lesson to be learned is that objective information on where the State is now and where it is likely to go is essential if support is to be gained for implementing change. Yet, since Territorial days, Wyoming has attempted to establish a central statistical office to gather, prepare, and disseminate basic data about the State, but to no avail. The concern must be with an objective appraisal about where the State is with regard to its people and its economy, in addition to a concern about where people might wish it to be. Only then can effective planning be done and effective decisions be made to ensure appropriate responses to change.

High on the list of requirements for adequate planning and adjustment to change is a better understanding of the forces of change, the role of human resources in responding to the shocks of change, and of the basic social and economic structure of Wyoming. Attainment of this understanding requires more research about people —why they move, where they move, their skills, ambitions and motivations; it requires data about the impact of economic and social change on people and on their ability to adjust to change.

Wyoming has had a unique economic and social history and has made some significant contributions to society. Much could be said about the outstanding success and development of many important human resource programs in the State. Emphasis here has necessarily been on those areas of particular importance in the immediate future, and many of these areas require action and improvement. The extent to which Wyoming will develop in the future depends very largely on the optimism and objectivity of its human resources —optimism to respond positively to change, and objectivity not only to recognize and accept change but also to make constructive decisions based on the evidence of change.

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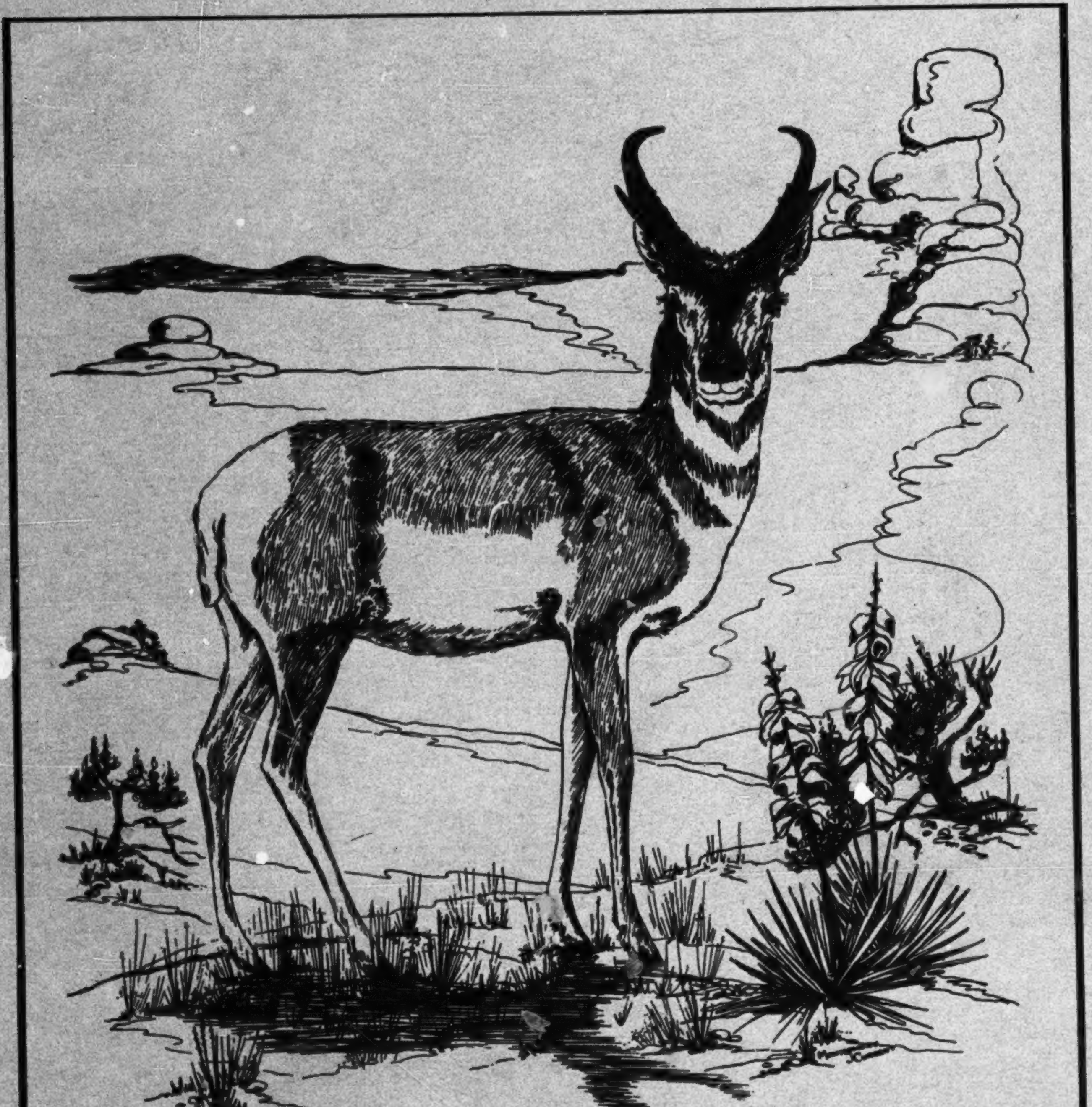
WYOMING GAME & FISH COMMISSION

CONSERVATION EDUCATION IMPROVEMENT PROJECT



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UNIVERSITY OF WYOMING
College of Education

VALUES OF WILDLIFE

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VALUES OF WILDLIFE

TEACHER'S DISCUSSION

In the United States, concern for the growth of cities and industrial regions, economic development and national security leaves little thought for wildlife resources of this great nation. A valuable resource is being destroyed without the realization that any devastation is taking place. How this can happen is easily understood when one realizes that large numbers of our citizens are unfamiliar with the animals giving them their milk, meat, butter and clothing. If this can happen, it is not surprising that they are not familiar with their country's wildlife resource.

wildlife: refers to all wild animals, whereas game animals are those species of wildlife which are the objects of sport, fishing or hunting

Wildlife resources serve as an index to the general condition of a country's natural resources. Where wildlife is abundant, natural resources have not been destructively utilized. Parts of Alaska and of Africa stand out as examples of countries with relatively unexploited natural resources and abundant wildlife. A scarcity of wildlife is coincident with destructive natural resource exploitation. Greece, Turkey and Lebanon serve as reminders of the close relation between centuries of destructive resource utilization and scarce wildlife resources.

Early in the history of the United States, wildlife provided food, clothing and trade material for the early settlers. Much of the early exploration of the continent was conducted by men exploiting the beaver and other wild animals for their furs. Professional buffalo hunters exploited the bison as food for the railroad construction crews during the middle 1800's.

Wild fur trapping is still being carried on today. However, competition from imported pelts from Canada and the Communist countries has depressed fur prices to such low levels that trapping is not profitable. Further lowering of fur market prices has resulted from the development of synthetic fur substitutes. Despite this, certain so-called wild short-hair furs like the mink, otter, fisher and marten bring high prices because of their scarcity. The United States does benefit from fur resources even though they may be imported. As the center of the retail fur trade industry in the world, the United States processes over 500 million dollars of fur products annually.

short-hair: furs which contrast with long-hair furs of the coyote, fox, wolf, etc.

Today in this country, game can no longer be considered as an important food item. Only in Africa is there a possibility for commercial utilization of the large game herds as food and then largely for the poorly-fed African.

Marine fish and shellfish resources have always been important to human populations living along coastal regions. Recently, they have become more important as a result of improved methods of preservation, rapid shipment to distant markets and new fish products. In 1962, over 5 billion pounds of fish were caught by the United States commercial fishermen. This amounted to a little less than 15 pounds per capita for human food and 15 pounds per capita as feed for poultry, dogs, cats, etc., fertilizer, cod liver oil and other commercial animal oils and glue. The recent development of low-cost fish protein concentrates as a diet supplement for underfed people of the world will markedly increase the value of the now low marketable segments of the fishery resource, such as mullet, buffalofish, carp, etc.

The consumption of shellfish has increased materially, primarily due to better shipping methods and deep freezing. The shrimp industry is the most profitable of all the fisheries, being valued at 70 million dollars annually. Other shellfish resources include lobsters, scallops, clams, oysters, and crabs.

Recreational values for wildlife have developed only recently. Thirty million persons spend nearly 4 billion dollars annually in pursuit of hunting and fishing activities in the United States. Except for the Great Lakes area, the freshwater fishery of this country is essentially important only as a recreational fishery.

Aesthetic values are playing an important role in increasing the recreational importance of wild animals. More and more people are hiking, taking canoe and horseback trips or visiting wildlife refuges and national parks, where wild animals are major attractions. The chief pleasure gained is seeing, studying and photographing wild animals in their natural surroundings. Bird watchers alone currently number over 11 million in comparison to only 13 million hunters.

More directly, biological values of wildlife are greater than we often realize. Lady bugs are raised commercially for helping control aphids on agricultural crops. Honey bees are utilized to achieve better cross-fertilization of trees, crops and garden vegetables. Birds and many rodents consume great quantities of insects. Meadowlark populations in California's Sacramento Valley are estimated to feed their young 193 tons of insects every day. Fish of the genus Gambusia feed on mosquito larvae so extensively that they are used as an important control of that insect. Beaver colonies build dams serving to store water which contributes to sustaining flows of springs and streams, as well as to sustaining desirable levels of the water table.

water table: the upper surface of the zone of saturation of ground water.

Survival Requirements for Wildlife

All wild animals have certain basic living requirements which must be met if they are to survive. The climate must be favorable Species adapted to hot, dry regions can not exist in cold, humid areas.

Food of the right kind and quantity for wildlife must be available during all seasons of the year. Turkeys must find insects for their young poults. Grass seeds and various nuts or fruits must be available for adult survival. Not only must this supply of food be successfully produced, but in the crucial winter months it must be accessible despite deep winter snows. The same is true for deer which are essentially shrub or woody plant feeders. If more grass is produced than browse, the deer starve. If deep winter snows cover the ground supplies of browse and the browse supplies on trees or tall shrubs are too high for the deer to reach, the required food is present but not available to the deer.

browse: woody plant food, usually consisting of the current year's

Brown trout, as small fish, exist by eating insects and other invertebrates. As they reach 12 or 14 inches in length, they must begin to feed on larger food items as a matter of energy efficiency. This means the larger trout must have available sufficient numbers of small fish of other species or they begin to eat the smaller brown trout. If small fish are relatively unavailable, the larger fish may become stunted, having large heads and small bodies, or the population will ultimately destroy itself with only a few large trout surviving by feeding on the smaller brown trout.

The swallow, bluebird, and nighthawks feed exclusively on insects. If these food supplies are destroyed by cold, inclement weather or by uncontrolled pesticide spray programs, the birds will starve or suffer from secondary effects of pesticides which may or may not be fatal. Fish which feed on insects are subject to the same hazards.

pesticide: lethal organic or inorganic chemical materials used to control or reduce undesirable animal species

In the winter, on occasion, deer will feed on hay mixed with other natural foods. Under severe winter conditions with deep snow, they are often found dead with stomachs full of hay and yet they died from starvation. This happens, despite the fact that deer are kept indefinitely in zoos on hay diets. Reasons for this are rather complex; however, the wild deer are generally able to eat browse because of small microscopic organisms in their stomachs that help them digest woody food. These microorganisms are so specialized they can only digest woody plant material and frequently only woody plant material from certain kinds of plants. There may be present those organisms for digesting other plants; however, those most abundant are the ones working on the most abundant food eaten by the deer.

The deer from the zoo are able to eat hay because the most abundant microorganisms in their stomach work only on hay. During the winter if the zoo deer were suddenly fed only browse instead of hay, they would likely die from starvation with a stomach full of browse. In both cases, the deer die, not because they could not eventually become adapted to new food under favorable conditions, but because they were unable to become adapted with a change in kinds of microorganisms in their stomach fast enough under harsh winter conditions before starvation. This is the reason that winter feeding of hay to deer does little good if that is all they have to eat. Something is wrong with their habitat if their natural winter food has disappeared or is completely unavailable.

microorganisms: bacterial and protozoan organisms are lumped together in this category

Cover is probably the most important consideration for a wild animal. The standing cornfield or grainfield provide concealment for the pheasants while feeding. The brushy fencerow provides the travel lane between the cornfield and the roosting areas.

Escape cover is necessary to protect wildlife from their enemies. The cottontail uses brush piles and brushy fencerows to escape its predators. White-tailed deer use forested areas and wooded river bottomlands as their escape cover. Small bass or perch need aquatic weed beds for cover to escape pursuit by large fish. In some areas, sunken car bodies and other artificial structures serve the same purpose. In marine areas, coral reefs and kelp or seaweed beds serve as escape cover for many smaller fish. Small birds use dense trees, bushes and grassy cover to escape their natural enemies.

Cover for breeding purposes is equally important. Without cavities in trees, fenceposts, or artifically constructed nesting structures, the house wren, bluebird, or wood duck may be severely hampered in nesting or may be unable to nest. Destruction of sagebrush, where sage grouse nest, means destruction of that grouse. Gravel bars are necessary as stream spawning sites for salmon and trout. Removal or destruction of those bars, destroys those fish. Draining of farm ponds, marshes and other wetlands eliminates cover vegetation necessary for successful nesting of the canvasback duck, the redhead duck and other water birds, as well as eliminating homes for muskrat, mink, etc.

VALUES OF WILDLIFE

Anyone having had a bird bath in his yard can appreciate the value of water to wild animals in their daily activities. Water may be scarce during drought and may be the cause of the death of many wild animals. Ironically, too much water is equally disastrous, particularly during the breeding season when the young are hatched or being born. Development of livestock water tanks in Wyoming has played an important part in increasing the numbers of pronghorns. In desert areas, covered cement rain water catchments called "guzzlers" have been responsible for providing water for quail during dry periods and thereby increasing their numbers. In sharp contrast, the increasing development of cities, urban areas, and agriculture have seriously encroached on the nation's wetlands by drainage and destruction of them in so far as wetland species of wildlife are concerned.

The quality of the water is as important as the proper water quantity. Mineral salts and silt carried in the water may reach levels where fish are unable to survive or where aquatic vegetation will not grow. Shallow, slow-moving streams or ponds may become too warm and thus become oxygen poor making them incapable of supporting animal and plant life. Chemical pollution may be toxic or it may reach levels which repel wildlife as effectively as if the water were not there.

Vertebrate and Shellfish Wildlife Resources of the United States

For discussion purposes our wild vertebrate and shellfish resources can be organized into three groups: farm and ranch wildlife; forest, rangeland and mountain wildlife; and freshwater and marine wildlife. The most common and widely distributed wild animals characteristic of each of these three groups are listed for your convenient reference.

The farm and ranch wildlife are the most important terrestrial group. This is understandable since 80% of the land available for wildlife habitat falls in this category. It is estimated that one-third of the total bird population in the United States is found on farm and ranchland. The meadowlark, chipping sparrow, savannah sparrow, vesper sparrow, starling, house sparrow, song sparrow, bobolink, horned lark, American goldfinch, brown-headed cowbird, robin, red-winged blackbird, common crow, warbling vireo, loggerhead shrike, house wren, barn swallow, kingbird, yellow-bellied sapsucker, common nighthawk, short-eared owl, mourning dove, ringnecked pheasant, bobwhite quail, killdeer, and red-tailed hawk are typical species. The garter snake, gopher snake, yellow bellied racer, leopard frog, toads and the tiger salamander are characteristic farmland-ranchland reptiles and amphibians. Typical mammals include cottontails, deer mice, gray and fox squirrels, red and gray fox, striped skunks, long-tailed weasels, raccoon, and big brown bats. The farm game animals are very important to the hunter since they comprise 68% of the total game animals killed. The principal species of farm game are the cottontail rabbit, the gray and fox squirrels, the ring-necked pheasant and the bobwhite quail.

The wildlife of the forest, range, and mountains include some of of our most important big game animals. Approximately 85% of all big game killed in the United States are evenly divided between white-tailed deer and black-tailed deer. About one-fifth of all game killed are killed on these lands. Common mammalian forest species include white-tailed deer (in the East), black-tailed deer (in the West), jumping mice, woodrats, deer mice, flying squirrels, chipmunks, coyotes, hoary bats, and silver-haired bats. Common representative avian forest species are the slate-colored junco, rufous-sided towhee, evening grosbeak, American redstart, yellow-throat, yellow warbler, golden-crowned and ruby-crowned kinglets, wood pewee, hermit thrush, red-breasted nuthatch, downy and hairy woodpecker, saw-whet owl, long-eared owl, great horned owl, yellow-billed cuckoo, and the sharp shinned hawk. Reptiles and amphibians commonly found in forested areas are gopher snakes, garter snakes, leopard frogs, toads, and tiger salamanders.

Rangelands are here considered to apply only to those semi-arid grasslands west of the 100th Meridian. Common species of birds typical of rangelands are horned larks, sage thrashers, Say's phoebe, burrowing owls, mountain plovers, prairie falcons, golden eagles, Swainson's hawks and the ferruginous hawks. Common species of rangeland mammals are the pronghorn, black-tailed deer, white-tailed deer, cottontails, jumping mice, pocket gophers, ground squirrels, and coyote.

Mountain wildlife are here considered to be those species that thrive only in relatively isolated and inaccessible regions. Characteristic mammals would be bighorn sheep, mountain goat, elk, mountain lion, gray wolf, wolverine, and the grizzly bear. Avian species would typically include the California condor, and the great gray owl.

Freshwater wildlife inhabit a variety of aquatic habitats such as swamps or marshes, lakes or ponds, and streams or rivers. Some animals are directly dependent on the water while others depend on the vegetation developed in or adjacent to the water. Characteristic mammals include muskrats, beaver, river otters, mink, long-tailed weasels and raccoon. Typical freshwater avian representatives are ring-billed gulls, herring gulls, common snipe, killdeer, sora, virginia rail, American bitterns, great blue herons, osprey, ruddy ducks, buffleheads, common goldeneye, lesser scaup, pintails, mallards, Canada geese and least grebes. The reptiles and amphibians typically consist of garter snakes, chorus frogs, leopard frogs, turtles and tiger salamanders. Major fishes are characteristically placed in two water temperature groups. The fish adapted to water temperatures above 64°F are warm water fish usually consisting of yellow perch, catfish, black bass, and crappie. Those fish adapted to water temperatures below 64°F are cold water fish characterized by rainbow trout, brown trout, brook trout, and whitefish. The carp and chub are important in quantity but not in quality in both warm and cold water habitats.

Having an extensive contintental-shelf, the coastal waters, bays and river mouths consist of shallow waters which support a large and valuable fishery. Off of New England, the haddock, flounder and halibut are very important along with lobster, scallops and clams. In Chesapeake Bay, the oyster is king. Around 66% of the United States' oyster harvest comes from Chesapeake Bay. The menhaden are the area's most abundant fish.

The important Gulf of Mexico fishery includes mullet, sheepshead and red snapper. The shellfish, shrimp, oysters, and crabs are also very important.

On the Pacific Coast the salmon, tuna, halibut, and mackerel are the most characteristic fish. Important shellfish are the dungeness crabs, oysters, and clams.

Those mammals typically found in the marine area are the California sea lion, elephant seal, hooded seal, harbor seal, manatee, dolphins, killer whales, humpback whales, blackfish and porpoises. Characteristic marine birds are the sooty shearwater, common loon, double-crested cormorant, petrels, old squaw, duck, surfscoter, red-breasted merganser and the herring gull. Typical reptiles of the sea include the green turtles and the leatherback turtle.

Problems of Wildlife Management

The very nature of our highly industrialized culture creates many serious problems for wildlife. It is estimated that farm and ranchland bird populations have declined from an average of two birds per acre in 1915 to less than two birds per 10 acres at present. One of the major problems is the destruction of cover or the destruction of a place for wildlife to live. Loss of irreplaceable cover has been the result of unwise drainage of large marshes, swamps, and wetlands for city expansion, housing development or agricultural development. Removal of roadside and fencerow vegetation by mowing and weed killing chemicals further reduce vital cover for wildlife. The use of mechanical harvesting machines leaves little cover in wildlife feeding areas.

Probably next in importance is the serious pollution of nearly every part of the wildlife environment. In a single year, one billion pounds of chemical pesticides may be sprayed over 100 million acres of agricultural cropland. Many of these chemicals are lethal.

Water pollutants consisting of chemical pesticides washed from agricultural lands into streams, rivers and oceans, oil wastes from industry and ocean-going ships, detergents from household and industrial sources, inadequately treated sewage, and many other pollutants are not only lethal to all forms of wildlife, but serve to destroy wildlife food supplies and cover.

Generally wildlife species which are valuable as objects of sport hunting or fishing are legally considered to be public property. Private ownership of these wild species is not possible. With more than 75% of the annual harvest of wild game and fur animals coming from privately-owned lands, a serious sportsman-landowner conflict is bound to arise. To protect his land from the army of hunters the landowner closes his land to hunting and fishing. Future hunting and fishing will depend on finding a solution to this very serious problem.

Harvesting of the game and fish resources must also be regulated to limit the harvest to not more than the annual increase of the wild animals. Game and fish laws regulating the harvest, the length of the time of the season, how the animals may be taken, and the number of animals that may be taken each day or in each season, must be respected and obeyed. Not only do these laws apply to hunters and fishermen, but they also apply to bait dealers, commercial fisherman, fur farm operators and taxidermists.

In summary, wherever adequate food, cover and water are available, a variety of wildlife will be abundant. An abundance and variety of wildlife indirectly means that proper use and management of soil, water, forest, rangeland, etc., is being practiced.

Suggested References

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*Russell, Franklin. 1964. Argen the Gull. Alfred A. Knopf, N. Y.

* Particularly good for story reading to children.

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RESOURCE UNIT

Wildlife Time Allotted ________________

Unit Objectives

1. To illustrate useful relationships between wildlife and man.
2. To emphasize our responsibility as citizens in caring for living creatures.

Concepts

1. Animals need food and shelter to sustain life.
2. Different animals require different methods for survival.
3. The existence of wildlife in man's environment is useful to him.
4. Man has the power to destroy or protect living creatures depending upon his interests and future activities.

Activities

Demonstrations and Investigations

a. "Wild" pets in classroom

b. Raise game birds

c. Polluted water and effects on wildlife

Field Trips

a. Observe homes of wildlife

b. Go to museum or zoo if available

c. Go to forest station or wildlife agency

d. Go to pond, river or creek to collect samples for aquarium

e. Collect samples of wildlife for a terrarium

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. Wildlife needs and requirements	Activity: Polluted water and effects on wildlife.
A. Shelter for protection 1. Types of habitats 2. Weather effects on animals 3. Predator effects 4. Man's requirements compared to wildlife requirements	
B. Food chain concepts 1. Range-habitat relationships to food chain.	Film: Animal Habitats
II. Uses of wildlife by mankind	
A. Food and clothing 1. Meat source 2. Clothes from fur, feathers, and hide	
B. Ecological balances and cultivation	Field trip: to wildlife homes
C. Pleasure and enjoyment for rich life experiences 1. Outdoor activities a. Hunting b. Fishing c. Observing d. Photographing	Films: Animal Tracks and Signs; Life in the Forest
III. Wildlife is often destroyed because of man's interest or carelessness	
A. Cities, roads and other structures remove habitat	Film: Life Along the Water Ways
B. Farms remove habitat yet may provide for other forms of wildlife	
C. Wastes from cities, farms, mining and manufacturing pollute waterways which provide special habitat for animal life	Discuss Activity: Polluted water and effects on wildlife

IV. Wildlife most useful to us can be protected

- A. Laws help provide
  - 1. Personnel to direct and carry out wishes of the citizens to protect wildlife
  - 2. Refuges to protect ranges, nesting grounds, breeding grounds and the like
  - 3. Financial aid to carry out planned protection
    - a. Research
    - b. Land purchases

Field trip: to wildlife conservation agency or invite a wildlife conservation agent to talk to the children

- B. Individuals can help
  - 1. Obeying game laws
  - 2. Keeping litter out of wildlife habitats such as parks, forests, waterways, etc.
  - 3. Being careful with fires while in the wilderness
  - 4. Treating all life with respect since it cannot be replaced once destroyed

Read to children: A Zoo in My Luggage; Argen the Gull

EQUIPMENT LIST FOR SUGGESTED ACTIVITIES

Quart jar - 4

Cages or boxes for wild pets

Terrarium or aquarium

Access to incubator or setting hen

Snails

Freshwater algae

SUGGESTED ACTIVITIES

Demonstrations and Investigations

Wild Pets

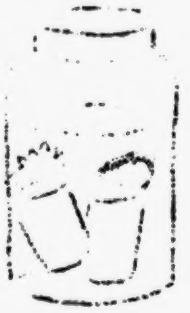
1. Keep a "wild" pet in the classroom for a short time. A ground squirrel, frog, toad, turtle, field mouse -- are often quite happy in temporary captivity. Not all wild animals are suitable for this purpose, particularly birds. This should be made plain to the children. After a short "visit" the animals can be returned to his proper environment. Frequently, some person in a community may have a "wild pet" they will loan the school. During the "visit" the children can learn the needs of the animal: water, food, shelter; and can learn to appreciate the value of each small life.

Raising Game Birds

2. Contact Game and Fish Commission for permission to raise game birds. A local hatchery would probably be able to hatch the eggs for the class. Close acquaintance with game birds helps to develop respect for all life and an awareness of the needs of wildlife. Children can discuss care of birds and set up a chart to take turns in assuming responsibility for their care. Further discussion of how birds are cared for in the wild will increase childrens' knowledge and appreciation of provisions that must be made to protect wildlife.

Suggested questions: How do birds find shelter in the woods or fields? What kinds of plants furnish shelter? How do they get food and water? What are their enemies? How may they be protected from their enemies? How can people help birds that live in the woods and fields? When birds are mature, a suitable locality may be selected to release them. Children should consider whether or not the locality provides food, shelter, water, and protection.

3. Use four quart jars. Fill partly with water. Ask the children to suggest the types of things picnickers sometimes throw in streams (old tin cans, partly eaten food, paper cups, plates, newspapers). Add some of these things to the jars and allow it to remain for several days. Put some water snails in each jar, including the control.



tin cans

paper plates and cups

food

newspapers

Helpful hints: Allow the children to observe the effect of litter on life in the streams. Minnows or other small fish might be used in place of the snails if the children would not object to their untimely death. Discuss the effect of litter on pond or stream life. Ask about the effect it might have on other wildlife that came to the stream to drink or on any animals that ate stream or pond animals. What would happen to the birds that lived along the stream? What would happen to people that drank the water or ate fish that lived in the stream?

Other Suggestions

4. Write your State Game and Fish Commission. Ask them to send you material about wildlife in your vicinity. Some states will send film, speakers, and traveling exhibits.

5. Start an Audubon Junior Club. Write Audubon Society, 1130 Fifth Avenue, New York, N. Y. This society publishes the Audubon Junior News which is issued during the school year. The purpose of this society is to advance public understanding of the value and need of conservation of soil, water, plants, and wildlife, and the relation of their intelligent treatment and wise use to human welfare. Any group of ten or more children with an adult leader, may form a club.

6. Students may make reports and studies envolving game animals. Find out what food one animal lives on (this may be done with the help of a biologist). Then discuss killing the food the game animal needs for existence.

Field Trips

1. Make a field trip to a neighboring area where you may observe homes of wildlife, areas there they feed, tracks.

2. Make a field trip to a museum to see animals in their natural habitat.

3. Make a field trip to a forest station and talk with a ranger.

4. Make a field trip to a pond or river in your vicinity. Collect samples of pond life. Relate to food chains. Set up an aquarium in your room.

5. Make a field trip to an area outside your community. Collect material for a terrarium. Example: from a desert area: cactus, lizard, small snake, beetles, plants.

Helpful hints: Each community will have a different situation. For some communities a trip to a wild area is difficult. In these instances, films may have to be substituted for larger animals. Almost every community has some evidence of a wild community, however. A vacant lot, an ant hill in a backyard or in the crack of a sidewalk. Some effort should be made to put the children in contact with the multitude of wildlife on this planet that lives or tries to live independently of man.

SUGGESTED VISUAL AIDS

Films

Animal Habitats, 11 min., color, FAC.
Animal Tracks and Signs, 11 min., color, EBF.
Arctic Wildlife Range, 20 min., color, Thorne.
The Beaver, 11 min., color, EBF.
Big Land Animals of North America, 11 min., color, EBF.
Common Animals of the Woods, 11 min., color, EBF.
Gray Squirrel, 10 min., color, EBF.
Learning About Bears, 11 min., color, EBF.
Life Along the Waterways, 11 min., color, EBF.
Life in the Forest, 11 min., color, EBF.
Migration of Birds -- The Canada Goose, 11 min., color, EBF.
Moose Baby, 13 min. 30 sec., color, ABP.
Mother Deer and Her Twins, 11 min., color, EBF.
Pelican Island, 28 min., color, NGF.
The Snapping Turtle, 11 min., color, EBF.
Wyoming Wings, 27 min., color, WGF.
Wyoming's Wealth of Wildlife, 15 min., color, WGF.

Film Loops

Common American Birds -- Robin, 3 min. 20 sec., color, Ealing.
Elephant Seal, 2 min. 30 sec., color, Ealing.
Goldeneye -- Tree Nesting Duck, 4 min., color, Ealing.
Pronghorn Antelope, 1 min. 30 sec., color, Ealing.
Salmon Run, 4 min., color, Ealing.

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

Office of Information
Fish and Wildlife Service
U. S. Department of Interior
Washington, D. C. 20240

Regional Director, Southwest Region
Bureau of Sport Fisheries and Wildlife
Fish and Wildlife Service
U. S. Department of Interior
Box 1306
Albuquerque, New Mexico 87103

Information Officer
Bureau of Land Management
U. S. Department of Interior
Washington, D. C. 20240

Chief, Information and Education Division
Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

Conservation Chairman
The Garden Club of America
598 Madison Avenue
New York, New York 10022

Director of Information
The Izaak Walton League of America
1326 Waukegan Road
Glenview, Illinois 60005

Director of Education
National Audubon Society
1130 Fifth Avenue
New York, New York 10028

Chief, Conservation Education Division
National Wildlife Federation
1412 Sixteenth Street, N. W.
Washington, D. C. 20036

CONSERVATION EDUCATION IMPROVEMENT PROJECT

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UNIVERSITY OF WYOMING
College of Education

WATER

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WATER

TEACHER'S DISCUSSION

Water occurs in various forms: ice, snow, rain, etc. It is well to discuss these forms with the children so they will understand that rain is not the only source of water. A bulletin board display featuring the Water Cycle, as illustrated in Fig. 1, can help the children comprehend the relationship between atmospheric water and their own home-city water supply.

The amount of surface run-off after a rainstorm is determined by the length of time the storm lasted, its intensity, the topography of the land surface, vegetation present, and soil characteristics (Fig. 2). Water absorption capacities of the soil decrease when organic matter is destroyed through fire, trampling or tillage. The presence of organic matter in soil increases its water-holding capacity, helps bind the soil particles together, assists in developing granular soil structure, and helps eliminate puddling of water on the soil surface.

topography: the surface features or relief of the land

soil structure: small soil particles clump together to form larger particles; the larger particles may take such forms as small prism-like columns or perhaps nut-like granules; other shapes may be found depending upon the physical and chemical nature of the soil

Snow must first melt to release its water content. The rate of melting may be retarded by the shading of the ground and reduction of wind movement caused by the presence of vegetation. Slow melting of snow aids absorption rate by allowing the water to penetrate the soil slowly and become suspended as subsurface water. If the subsurface water, which is held by molecular attraction between the soil particles in the pore spaces, is overcome by gravitational forces, the water moves downward into the lower soil zones until it finally reaches the water table (Fig. 3). The depth of the water table in the soil varies with the soil's characteristics and the surface vegetation. Therefore, ground water is dependent upon the quantity of precipitation and infiltration capacity of the surface soil and on the ease of percolation through the soil strata. The capillary fringe of the water above the water table is dependent upon the soil texture.

infiltration: act of penetrating

Ground water has been used for centuries to supplement existing surface supplies. However, as ground water is used, the aquifer may have such characteristics as to prohibit rapid movement of water through the strata to recharge the well as fast as the water is being used. The cone of depression (Fig. 4) which is created may be such as to cause the wells to be deepened in order to maintain the water supplies. However, deepening the wells increases pumping costs which may be high enough to abandon the wells rather than have them deepened. For example, nearly 50,000 acres of land were removed from irrigation farming in Arizona during 1954-59 because of falling well levels which increased the cost of

aquifer: water-bearing rock

cone of depression: a dimple in the water table which forms when water is pumped from a well

WATER CYCLE

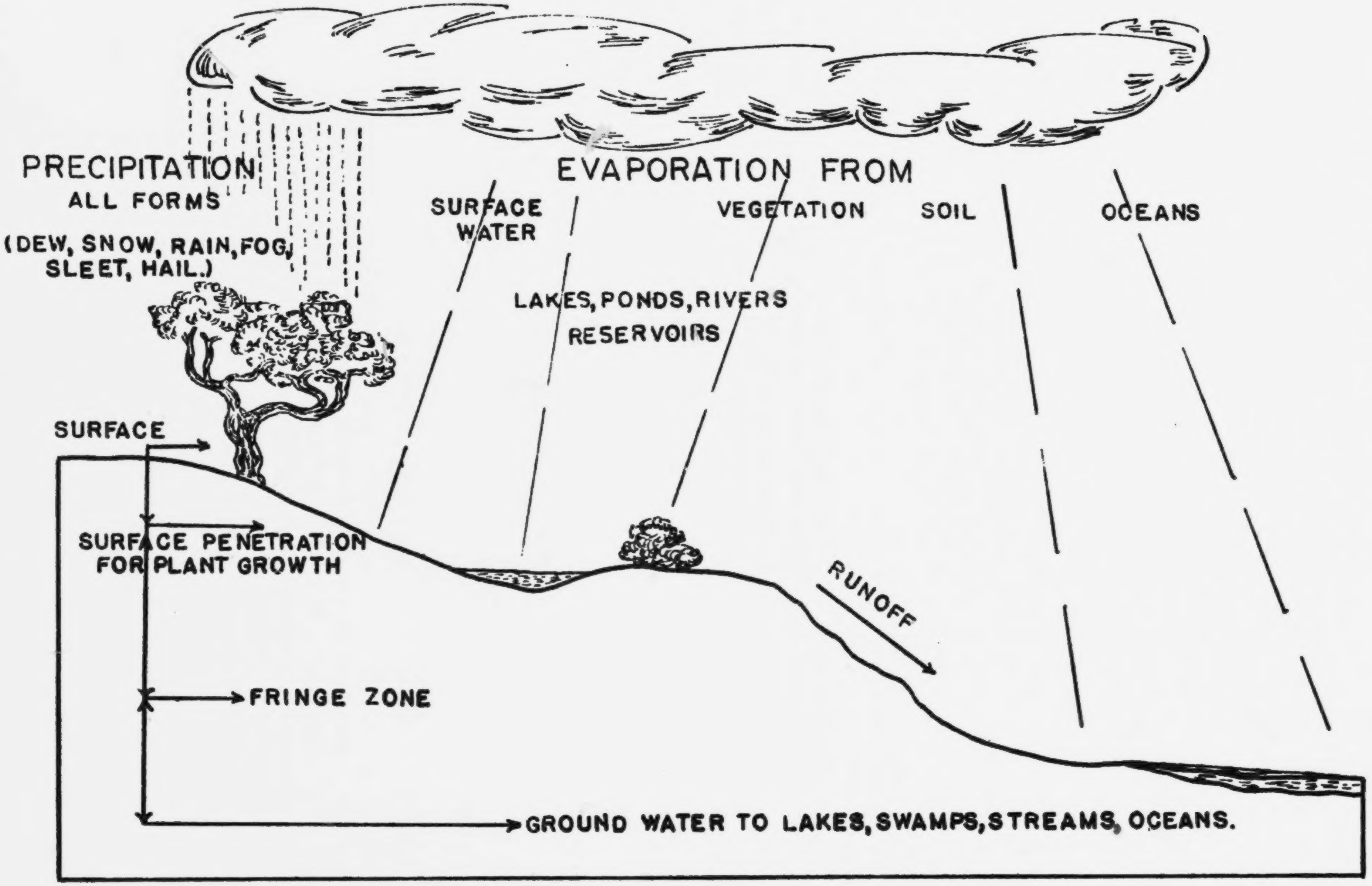

PRECIPITATION
ALL FORMS
(DEW, SNOW, RAIN, FOG, SLEET, HAIL.)
EVAPORATION FROM
SURFACE WATER
VEGETATION
SOIL
OCEANS
LAKES, PONDS, RIVERS
RESERVOIRS
SURFACE
SURFACE PENETRATION FOR PLANT GROWTH
RUNOFF
FRINGE ZONE
GROUND WATER TO LAKES, SWAMPS, STREAMS, OCEANS.

FIG. 1

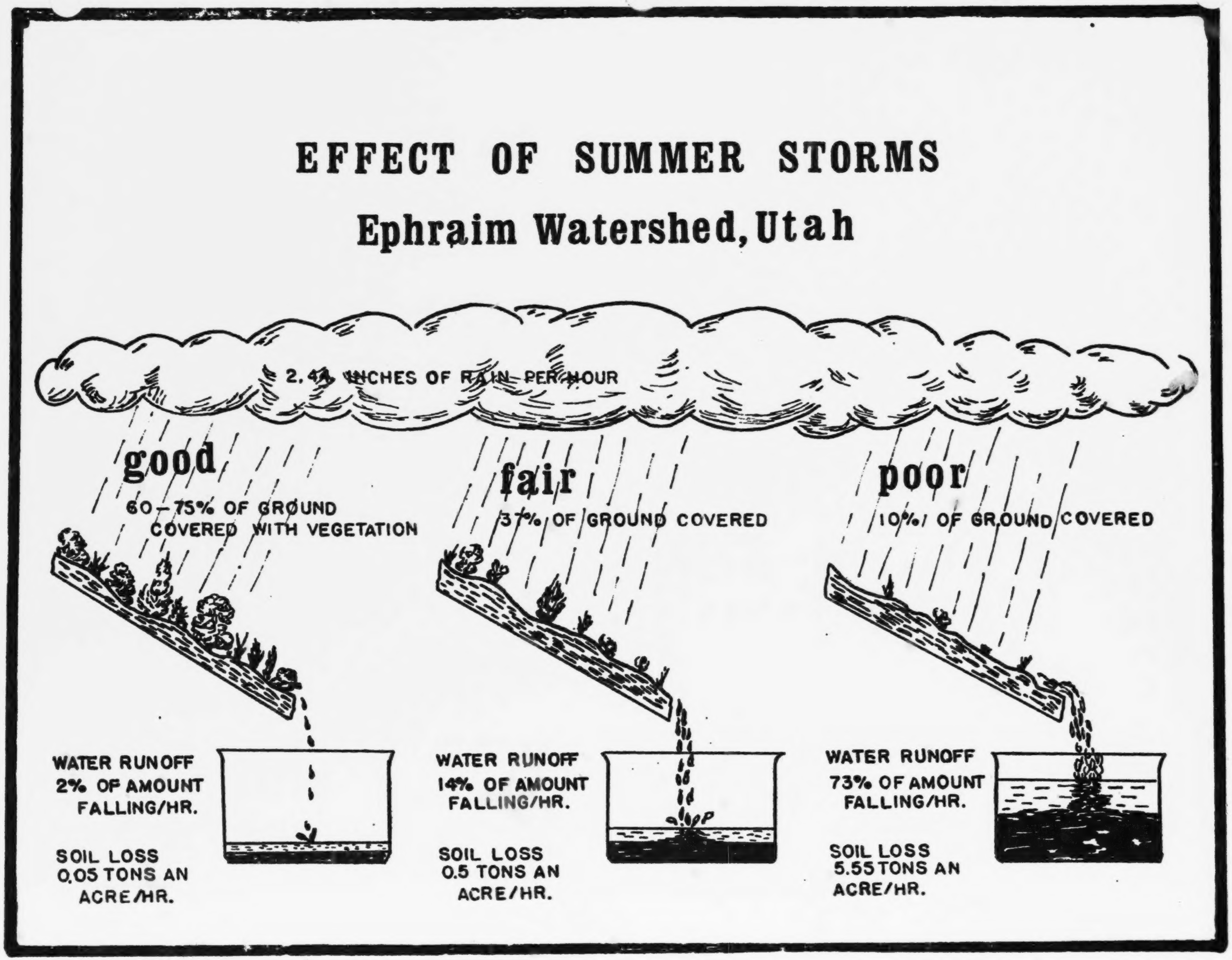

EFFECT OF SUMMER STORMS
Ephraim Watershed, Utah
2.44 INCHES OF RAIN PER HOUR
good
60–75% OF GROUND COVERED WITH VEGETATION
fair
37% OF GROUND COVERED
poor
10% OF GROUND COVERED
WATER RUNOFF 2% OF AMOUNT FALLING/HR.
SOIL LOSS 0.05 TONS AN ACRE/HR.
WATER RUNOFF 14% OF AMOUNT FALLING/HR.
SOIL LOSS 0.5 TONS AN ACRE/HR.
WATER RUNOFF 73% OF AMOUNT FALLING/HR.
SOIL LOSS 5.55 TONS AN ACRE/HR.

FIG. 2

WATER ZONES

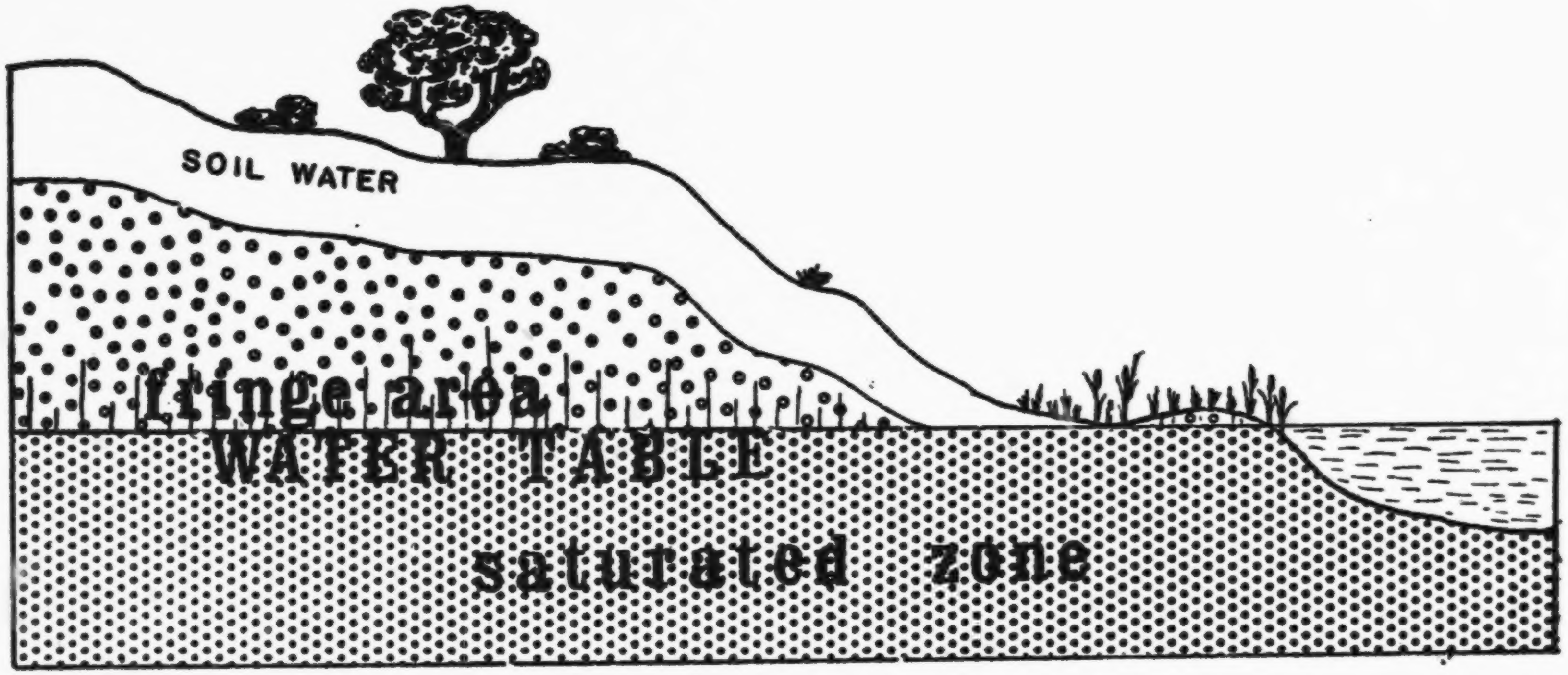

SOIL WATER
fringe area
WATER TABLE
saturated zone

FIG.3

GROUND WATER

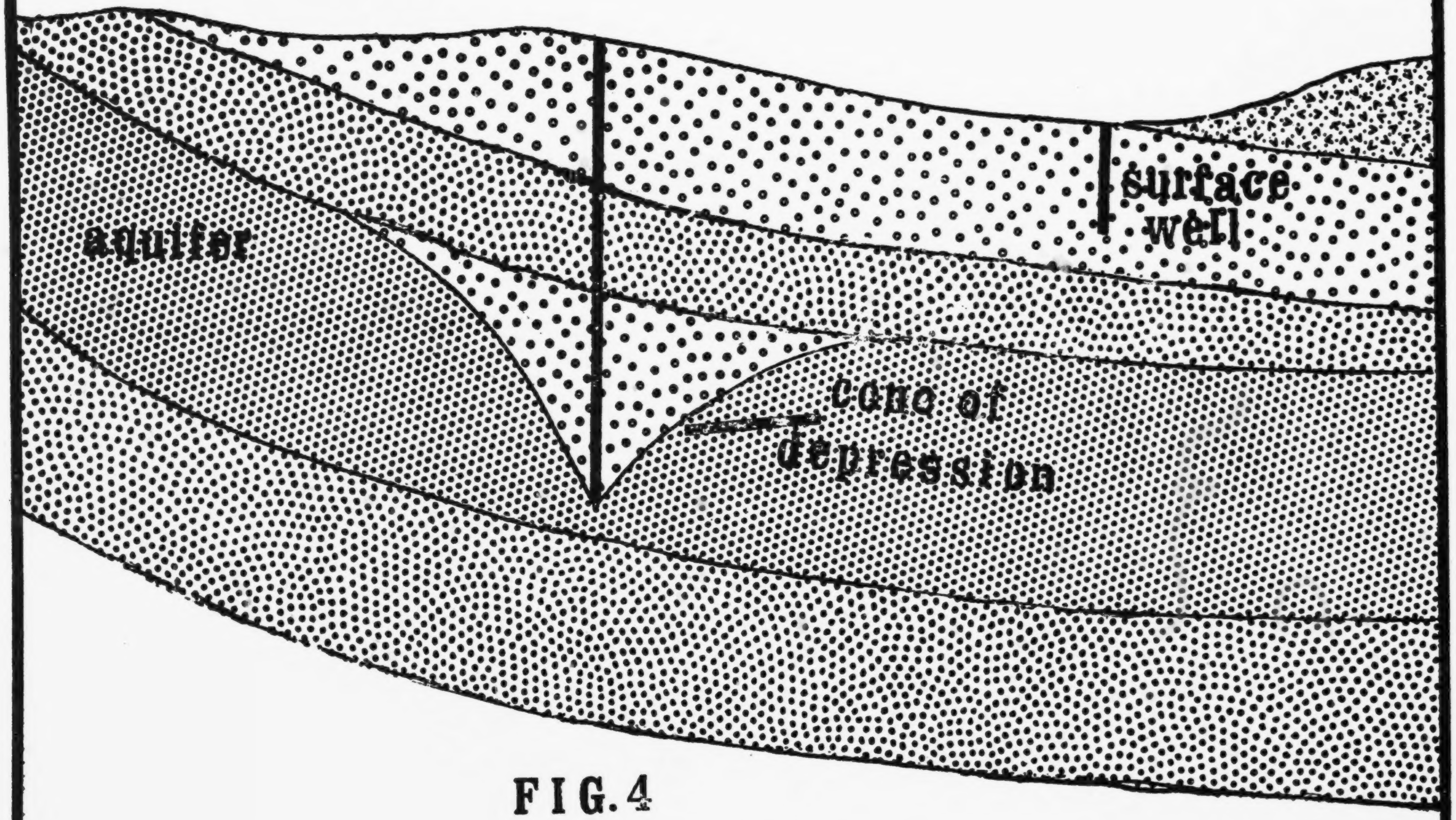

aquifer
surface well
cone of depression

FIG.4

lift above economic feasibility. In 1948 the farmers in that area were obtaining water at 100 feet, but by 1955, the average lift was 250 feet.

Aquifers frequently require many years to recharge. Sometimes the source for the recharge comes from distant points which prevents the water from moving into the depleted area for many years. For example, in the red beds of the Ogallala formation along the Texas-New Mexico border on the Texas side in 1940, 2,180 wells were in operation. By 1953, however, there were more than ten times this number in existence. The well levels fell 50 to 80 feet during that 13-year interval. The aquifer of the region is such as to prevent recharging in sufficient volume to maintain water levels. Therefore, the water is being mined at a rate which will probably exhaust the red beds, which are only 350 to 500 feet thick, within this century. Unfortunately, the red beds will not be usable again for several centuries while the aquifer is being recharged.

City Water Supplies

A resource person from the city water department may volunteer to conduct the class on a tour through the water works of the city, to show the pupils where their household water comes from and how it is treated before use. It might be well to point out that treating the water implies it is not safe to drink in its raw form. A discussion on what may be found in water that is harmful can be logically developed after such a trip. Signs of polluted water may be in the form of bad tasting water, settleable solids, odor, scum, foam, oil slicks, etc. Not all forms of pollution are easily detected, however, such as the presence of harmful bacteria and algae.

Most city water works are designed on the same principle. Settling basins receive water from the affluent or intake lines. In the receiving basins silt and clay settle out of the water (a series of basins is generally used; they are dried and cleaned periodically). The water is then piped to a flocculation tank where flocculating agents are added to remove any remaining solid particles that may yet be in the water. Finally, the water is filtered through sand and chlorinated. The amount of chlorine added to the water depends on the amount of contaminating organisms present in the water. Thus treated, the water is placed in the city mains for distribution to storage tanks or reservoirs to be ultimately used by the consumer.

flocculating agents: chemicals causing foreign particles in the water to clump together, forming a mass heavier than water, which can settle out easily; a commonly used flocculating agent is potassium aluminum sulfate, otherwise known as alum.

Water Use

Water, of course, has obvious uses, but children at this level are more likely to relate water use to the uses made around their home. An idea of how much water each individual class member uses in his home could assist in developing a better awareness of the value of water. This concept will best be taught by using investigation No. 4 in the Activities Section, "Water Uses in the Home".

Water may be rather permanently removed from existing surface supplies through such uses as farm crop production, manufacturing of products that incorporate water in the finished form, plant use through loss by transpiration, and evaporation and seepage loss upon transportation of the water through canals and irrigation ditches. Industrial use is mainly one of reuse rather than consumption, for the manufacturing of products requires water to be used primarily for cleaning, cooling, washing, or dissolving purposes. Only a small amount of water (about 2 percent) will actually be consumed during the manufacturing process. Further, although they require large volumes for their populations, cities remove only about 12 percent of the water they use from the water course. Hence, our water flowing in rivers is reused many times before it reaches the sea. Therefore, the most frequent cause of water shortages is insufficient quality rather than insufficient quantity. Other causes of water shortages include the uneven availability of water during the course of the year, uneven distribution of precipitation across the country, and limited water works facilities.

Water levels drop in the stream beds during the summer months when the watersheds are nearly empty of their storage and at a time when the peak demand for water is reached. Too frequently cities do not have the distribution facilities or storage facilities to handle the demand during the peak load months. Rationing of water is the only recourse open to provide for human needs and increased fire danger at the same time during these peak load months.

When used water is returned to the water course the waste or contaminants from the uses made of the water are returned along with the water to be diluted and dispersed. Eventual breakdown of the organic pollutants and removal of inorganic substances can occur if the volume of stream flow and the oxygen content of the water is relatively high. The microorganisms which dispose of organic pollution use oxygen for metabolism of the organic pollutants. The amount of organic matter present then determines the oxygen requirements of the microorganisms. The oxygen requirement is called the biochemical demand. Thus, the greater the pollutant load, the more oxygen required or the greater the biochemical demand.

metabolism: the chemical reduction of the complex organic material in the environment into simpler compounds for use as food for the growth of the organism

If the water is warm, however, as in the summer months, there is less dissolved oxygen in the water. Hence, if the flow of water is not sufficient for flushing purposes and the oxygen content is low, organic pollutants and inorganic substances tend to accumulate. This accumulation of inorganic pollutants creates toxic conditions in the environment, which reduce the number of beneficial microorganisms able to metabolize the organic pollutant load. This condition adversely affects the breakdown of those organic pollutants. A cycle of water deterioration thus develops, decreasing the quality of the water sometimes beyond the point of recovery.

Destructive Activities of Uncontrolled Water

The term erosion implies the removal of soil from a particular location and transportation of that soil into the water course to be subsequently deposited elsewhere in a stream or at the mouth of a river. Natural erosion is a geological process wearing away the soil about as fast as the soil builds up. The erosion which is considered here in this discussion is accelerated erosion created by man's manipulation of his environment to produce the necessities for sustaining life and to expand his living area to accommodate greater populations.

Three basic forms of erosion are identified with water erosion: gullying, rill erosion, and sheet wash. Gullying is most readily observed and is easily identified along road cuts or hillsides void of vegetation. Rill erosion generally gives way to gullying and is a series of small channels in the soil surface caused by the removal of the surface soil by running water. Sheet wash or sheet erosion is caused by the floatation of small particles of soil enmasse down from the upper reaches of a slope, gradually giving way to rills then gullies. Changes in color, texture of the soil, or reduced plant growth are common symptoms of sheet erosion.

Loss of soil through erosion creates poor soil conditions for sustained growth of vegetation and pollutes the water course by increasing the silt content of the water. An example of this is revealed in a watershed study at the Wagon Wheel Gap in the Colorado Mountains. The forest of one watershed was clear cut and stream flow measurements were made and compared to the previous nine years' measurements. Even though aspen sprouts took possession of the area a year after the cutting, the total run-off during the next few years increased 15 percent. The flood crests were raised 58 percent and were about three days early. The increased run-off may have been desirable from a watershed management position, but the silt load increased 7½ times the original amount. Excess soil damage apparently resulted and was not checked until the area was revegetated. The silt content of the stream had an undesirable effect on the fish population and aquatic life for several years following the logging operation.

clear cut:total removal of trees in a particular area

Three factors influence the erosive capacity of falling water: (1) quantity and intensity of the precipitation, (2) diameter of the falling water drops, and (3) velocity of the drops. The amount of soil placed in motion by the moving water varies directly with the square of the velocity of the drop. The ease with which soil detaches itself is dependent upon the permanent characteristics of the soil type which help determine the particles' size and shape.

When a raindrop strikes bare ground, its force of impact causes fine particles of soil to be picked up to form a drop of muddy water. The water drop, as it sinks into the soil, has the fine soil particles filtered out, thus plugging the pores of the soil at the surface. The accumulating water (puddling) at the surface being unable to penetrate the soil gives rise to the concentration of run-off creating accelerated storm flows on sloping ground.

As the slope of the land increases, factors for greater infiltration of the water into the ground tend to be less effective as increased storm flows develop. Slope, however, is of less importance in reducing effective water penetration if the cover is adequate, intensity of the precipitation is less, or the inherent soil characteristics are favorable for absorption. Orientation of the slope influences the water cycle and absorption run-off relationships as the southern slopes are much warmer and drier than northern slopes.

inherent soil characteristics: soil characteristics which result from the type of rock the soil has developed from, and the kinds of chemicals present in the soil

Soil particles influence the porosity and infiltration capacity of the water. The spaces between the particles hold air or water. Fine-textured soils have greater total porosity than coarse-textured soils, but because of stronger molecular forces generated by small-pore spaces, the water will not move as rapidly through the finely textured soil, but is held more firmly in place between the particles of soil.

Falling drops splatter the soil reducing clods to smaller particles. The land gradually covers with water and the raindrops keep up turbulence in the sheet flow and help keep the dispersed particles in motion, thus removing them more easily. Soil seen on foliage or foundations of buildings reveal the effects of splashing. Organic matter on the soil provides for the interception of the falling water, which breaks the force of the drop and anchors the soil to the extent that any splashes that occur will only be clear water which can penetrate the soil without plugging it.

Precipitation intercepted by the crown of trees during a storm may be as high as 37 percent of the total release. The factors that control the degree of interception are: composition, age, condition of the stand, and the season of the year (bare branches intercept less than those with leaves). Interception data is not readily available on foliage other than trees, but such interception evidently has great effect on the water cycle (Fig. 2).

The United States Department of Agriculture and other agencies have investigated run-off and water-flow retardation and soil erosion prevention from the effect of land use treatment over the last 60 years. The earliest work was restricted to forest lands. However, the scope of the investigations has widened to include agricultural lands also. The basic relationships between land use and run-off, debris deposition, shoaling of streams, channeling, silting of reservoirs, storm flows and other features following logging, cultivating, grazing, and burning have become better understood through these studies.

shoaling: making shallow

Management Practices

Water management is directly related to the use made of the land upon which the water is placed. What is to be done with the land will determine the method of water control.

The water which drains into a stream which flows past a point of interest is from the watershed of that point. Small watersheds are divided from each other by high points or divides. Small watersheds are a part of a much larger watershed (Fig. 5). The more even the flow of water that comes from the watershed, the more control we have over the influence and effects of the run-off.

Tilled land is subject to water damage, while forests and grasslands are less so because they are better protected. The more the soil surface is exposed, the faster the water runs off and the more soil it carries with it. Soil erosion from the watersheds leading to dams have long been known to furnish large quantities of debris in extensive areas of the country. In some of the Great Plains reservoirs as much as 2 percent of the reservoir's storage capacity can be lost each year. Twenty percent of all dams rely on storage alone for their usefulness. However, more emphasis has been placed upon other uses in recent years such as recreation and power. Nearly 83 percent of our reservoirs will be declared of no further useful storage purpose in 200 years. The cost of building these for the most part will not be paid off in that length of time. In Austin, Texas, the reservoir behind Austin Dam lost 95 percent of its original capacity in 13 years. Lake Waco, built in 1930 for municipal water supply, in only six years lost 20 percent of its storage capacity.

WATERSHED

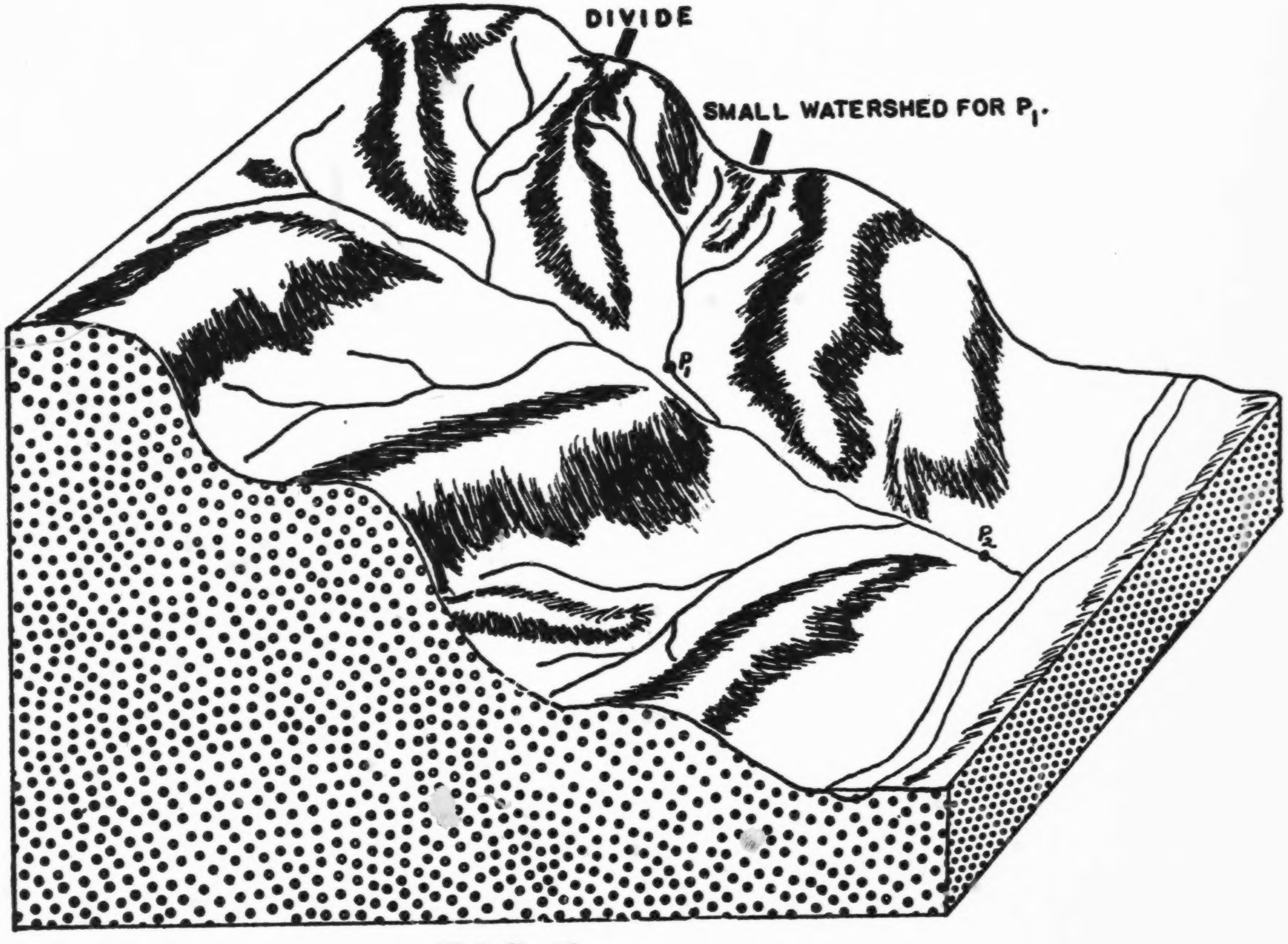

DIVIDE
SMALL WATERSHED FOR P_1.
P_1
P_2

FIG. 5

Reservoirs are constructed at the most economically and physically favored site possible; filling of a reservoir, therefore, indicates replacement in the form of new construction or dredging. New construction necessitates higher cost due to secondarily desirable sites, and dredging may cost as much as 50 times the original cost of the storage project.

Summary

Water is a renewable resource limited for use by its quality and quantity. Mismanagement of the watershed causes difficulties which increase financial burden, hardship, and often needless suffering. Sometimes the damage is irrepairable, or nearly so. The primary function of the conservationist is to design methods which renovate and protect the watershed, control excess water flows, and protect the soil.

Suggested References

Teacher's Reference Reading

Clawson, Marion. 1963. Land and Water for Recreation. Rand McNally & Co., Chicago.

Dasmann, R. F. 1959. Environmental Conservation. John Wiley & Sons, Inc.

Dasmann, R. F. 1965. The Destruction of California. Macmillan Co., N. Y.

Highsmith, R. M., J. G. Jensen, and R. D. Rudd. 1962. Conservation in the United States. Rand McNally & Co., Chicago.

Lynch, R. G. 1959. Our Growing Water Problems. National Wildlife Federation, Washington, D. C.

Smith, G. H., ed. 1965. Conservation of Natural Resources. John Wiley & Sons, Inc.

United States Department of Agriculture. 1955. Water, the Agriculture Yearbook. Washington, D. C.

United States Department of Health, Education and Welfare. 1960. Proceedings of the National Conference on Water Pollution. Washington, D. C.

RESOURCE UNIT

Time Allotted ________

Unit Objectives

1. To illustrate how the quality, availability and distribution of water supplies affects living conditions.

2. To illustrate the importance of protecting our water resources.

3. To improve individual awareness of responsibility in conserving water resources.

Concepts

1. Water comes to earth in many forms and reappears as many different sources.

2. A water source may be spoiled for future use by carelessness.

3. Our environment may be damaged by water.

4. Management of water supplies is essential for man's continual welfare.

Activities

Demonstrations and Investigations

a. Evaporation and water cycle
b. Water table and water cycle
c. Water and vegetation growth
d. Water uses in the home
e. Muddy splashes
f. Hold and drain
g. Detergents and pollution
h. Is your water contaminated

Field trips

a. Go to city water company
b. Go observe evidence of water erosion

WATER

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. Sources of water supplies	
A. Origin of water	Film: Water Cycle
1. Solid forms: ice, snow, hail, sleet	
2. Liquid forms: rain, dew	
3. Vapor forms: fog, clouds, steam	
B. Source of water	
1. Ground: springs, well, swamps, marshes	
2. Surface: creeks, rivers, ponds, lakes	
C. Source of city water supplies	Film: Water for the Community; A visit to the Waterworks
1. Treatment of water	
2. Distribution to homes	
II. Water Use	
A. Home	
1. Cooking foods	Activity: Water uses in the home
2. Thawing frozen foods	
3. Washing	
a. Cars	
b. Bodies	
c. Laundry	
4. Watering gardens and lawns	
B. City	Film: Water and What it Does
1. Restaurants	
2. Garages, etc.	
3. Fire Department	
4. Swimming pools	
III. Destructive activities of water to environment	Activity: Muddy splashes
A. Water erosion	
1. Types caused	
a. Gullies	
b. Sheet wash	
c. Rill	
2. Effects	Activity: Detergents and pollution
a. Loss of soil for crop production	
b. Pollution of water course by excessive siltation	
c. Excessive flooding of productive land	

III. A. 2. d. Destruction of city and town supplies, property and life

IV. Water management practices
  - A. Land control practices for improved watershed control
    - 1. Gully control
      - a. Check dams
      - b. Grassed waterways
      - c. Reseeding of vegetation cover after destruction or removal
        - (1) Forest
        - (2) Range
        - (3) Cover crops
    - 2. Stream bank reinforcement
      - a. Riprapping
      - b. Concrete banking where practicable
  - B. Direct water control practices
    - 1. Dams for trapping excess run-off for multiple use
      - a. Recreational use
      - b. Irrigation storage
      - c. Electric power
    - 2. Levies for confinement

Film loop: Flash Flood

Film: Adventures of Junior Raindrop

Field trip: to selected area around school to observe erosional evidence.

EQUIPMENT LIST FOR SUGGESTED ACTIVITIES

Teakettle

Hot plate

Quart jar -- 6

Aquarium

Coffee can with holes in the bottom

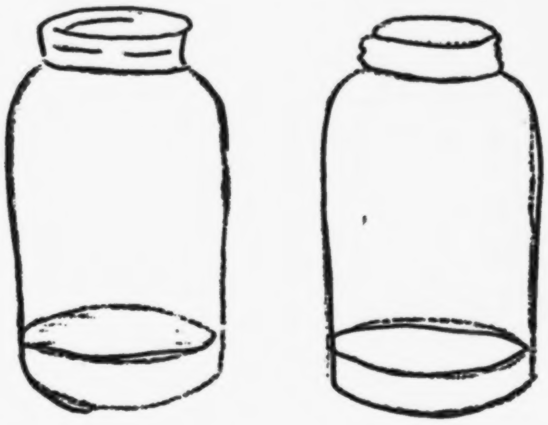
Aquarium "moss" -- freshwater algae

SUGGESTED ACTIVITIES

Demonstrations and Investigations

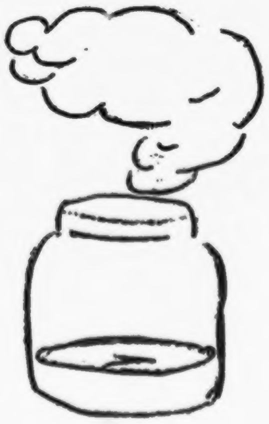
Evaporation and Water Cycle

1. A. Put one inch of water in two quart jars. Put a top on one jar. Leave the other jar uncovered. Look at the jars every day.



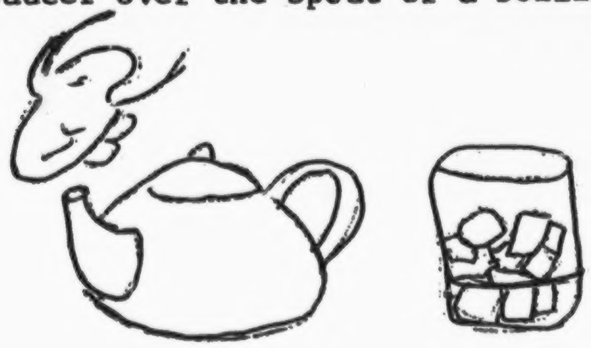
Helpful hints: Discuss the appearance of the jars with the children. Where did the water go from jar A? Why didn't the water leave jar B? Unscrew the top of jar B. Look at the drops of water inside the top of jar B. How did the water get to the jar top? The jar top stopped the water in jar B. Did the water that left jar A form droplets anywhere?

B. Put hot water in a jar. Put the jar outside the window where it is cool. Watch to see what forms above the jar.



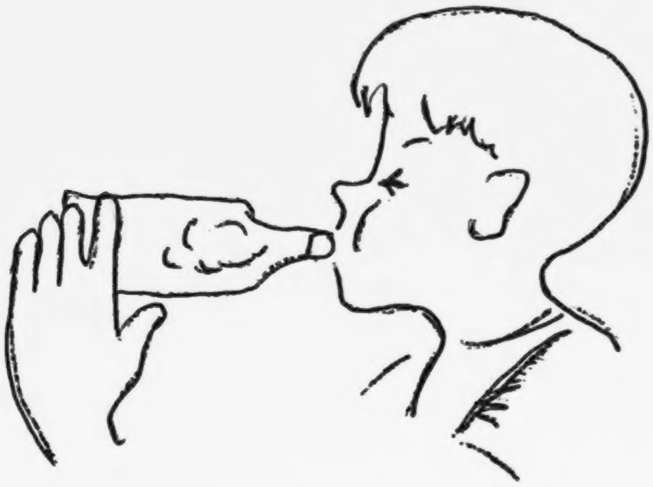
Helpful hints: Discuss results with children. Is the water leaving this jar? Where is it going? What happens to the water vapor when the cool air strikes it? These are little drops of water in the air. Do you ever see little drops of water in the sky? Clouds are many little drops of water in the sky. Does water come back down to us from the sky?

C. Fill a jar with snow or ice cubes. Allow to melt. Hold a cold saucer over the spout of a boiling teakettle of water.



Helpful hints: Discuss the form of water with the children. Water can be a solid, a liquid, or a gas. Snow and hail are solid water that comes back to us from clouds. Rain is liquid water. Clouds and fog are small droplets of liquid water. When water evaporates into the air it is a gas.

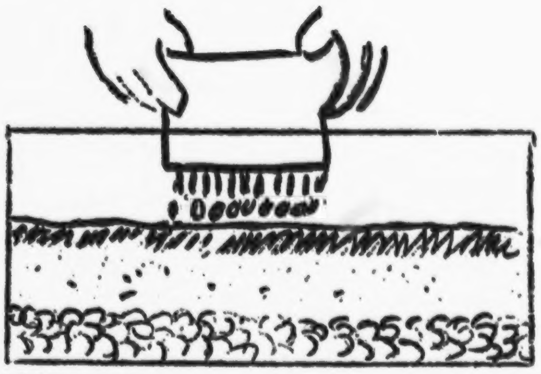
D. (Optional) Make a cloud. Rinse a clear glass bottle with water. (Transparent cold drink bottle). Do not dry. Drop a burning match down into the bottle. Let the match go out and smoke a little. Blow hard into the bottle to increase the air pressure in the bottle. Release the pressure suddenly.



Helpful hints: Discuss with children why the cloud formed. A few drops of water were left in the bottle so there would be water vapor in the air. The match smoke made particles in the air where the droplets could form. The increased pressure warmed the air slightly. The suddenly released pressure cooled the air and caused the water to condense on the smoke particles. A cloud was formed.

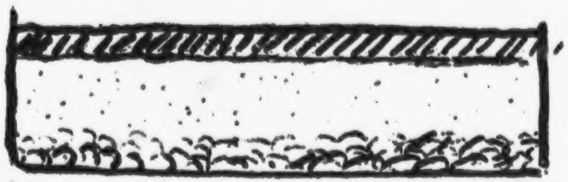
Water Table and Water Cycle

2. A. Put gravel, sand and dirt into an empty aquarium. Pour water in with a coffee can with holes in the bottom. Let the water soak down into the dirt until the water line covers the sand but not the dirt.



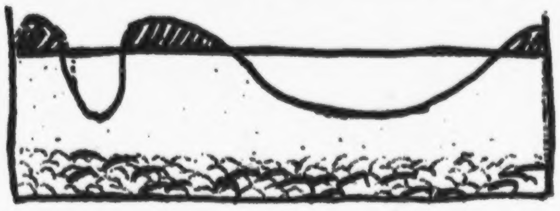
Helpful hints: Discuss with the children where the rain goes that falls on level ground.

B. Allow the aquarium to set overnight.



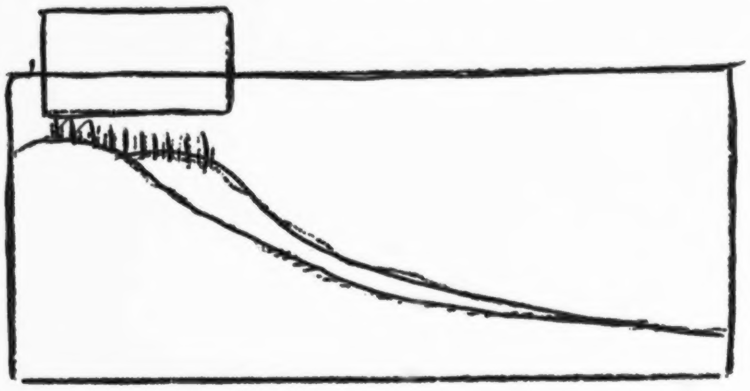
Helpful hints: The ground on top is dry. Is the water gone? Look at the water line under the topsoil.

C. Dig a well along the side of the aquarium glass. Make a lake at the other end of the aquarium.



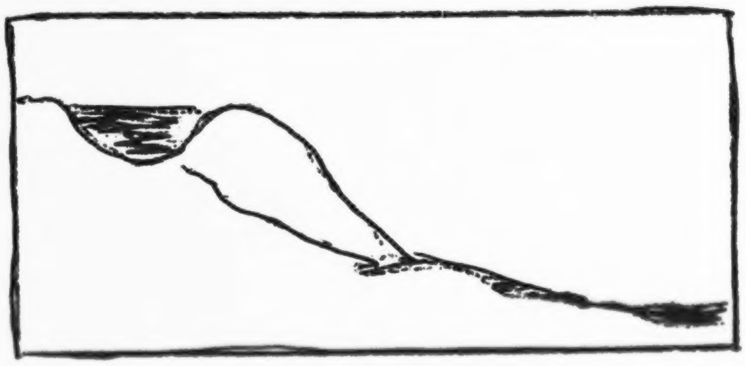
Helpful hint: Discuss where water in wells and lakes may come from. Call attention to the level of the water under the ground in relation to the height the water is in the well and in the lake.

D. Make hills on one end of the aquarium. Pack dirt firmly. Let the rain come from the coffee can fall on the hills. Watch the water run down to the lower end of the aquarium.



Helpful hints: Discuss ways rivers may be formed.

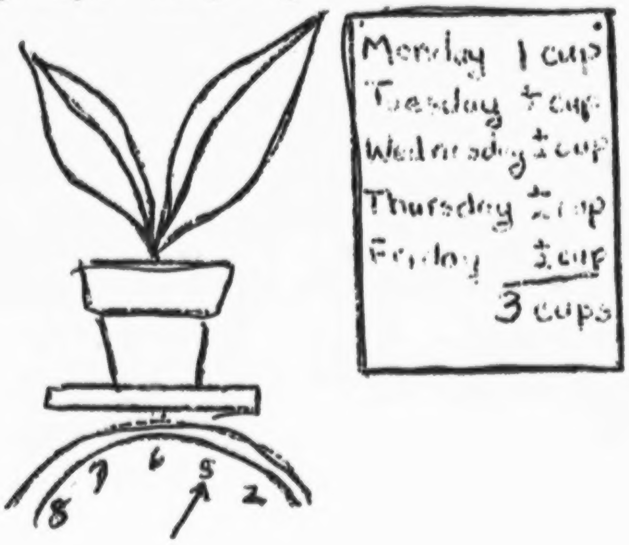
E. Make a mountain at one end of the aquarium. Pack dirt or sand firmly. Make a lake in the top of the mountain. Allow a child to make a hole into the side of the mountain near the base.



Helpful hints: Springs are another source of water. How does water travel to get to springs? Can water travel underground?

Water and Vegetation Growth

3. Weigh a small potted plant. Watch it grow for a period of time watering every day. Weigh again.



Monday 1 cup
Tuesday ½ cup
Wednesday ½ cup
Thursday ½ cup
Friday ½ cup
3 cups

Helpful hints: Discuss with the children the following questions:
(1) Where does the plant obtain its weight?
(2) How much water did we give the plant to make it grow this much?
(3) What does this tell us about the amount of water needed to grow a tree? A field of wheat? A garden? Grass for sheep and cattle to eat?

Water Uses in the Home

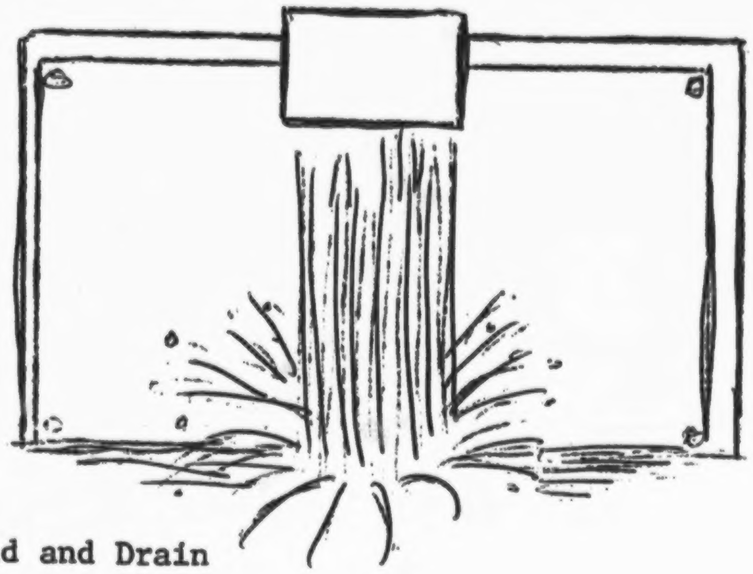
4. A. Have children ask parents to show them the water meter in their homes. Find out about how much water is used in homes. If the homes uses a well and pump perhaps parents can estimate water use for one month. Make a list of ways water is used in the homes.

Suggested list of water uses:
(1) washing dishes
(2) washing clothes
(3) baths
(4) cooking food
(5) showers
(6) toilets
(7) house cleaning
(8) watering lawn
(9) watering garden
(10) washing car
(11) filling wading pool
(12) playing with hose

B. Ask the children if anyone has a faucet that drips. (A drippy school faucet is preferable.) Measure how much water drips in five minutes. Use a measuring cup. (Teacher or parent may time for the child.) Figure out how much water is wasted by a drip in an hour, a day, a week, a month, and a year.

Muddy Splashes

5. Make a splash board. Tack a piece of white paper to a board. Stand the board upright in a patch of bare soils. Pour water on the ground near the splash board. Notice how high the drops splash the soil. Lay the board flat. Pour water on the ground beside the board. Notice how far away the drops splash. Try the splash board on the side of a hill. Notice that most of the splash goes downhill. Try the same series of investigations on ground that is covered with vegetation.

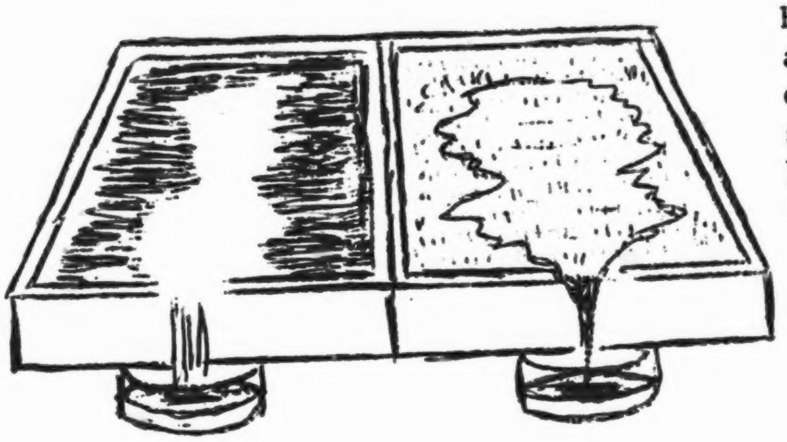


Helpful hints: Discuss with children the way raindrops erode the soil How much does vegetation protect the soil from erosion? Why does the Highway Department plant grass on road cuts? What might happen if no grass was planted on the road cuts?

Hold and Drain

6. Select sod 12" x 12" x 8" -- disturb as little as possible. Place in a cardboard box cut to allow container to be placed below. Select another soil clump the same size with no vegetation and place in a box. Pour water from a can with holes in it over each sample. Pour the same amount of

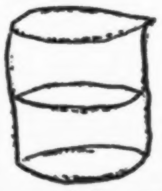
water on each. Notice puddling, splashing, gullying, etc. Allow to soak the soil. Continue to pour. Which holds more water on the top of the soil? Which allows penetration? Notice the amount of soil and water carried into the containers below.



Helpful hints: Call the childrens' attention to the carrying power of water. How does water move soil? Could this happen to a field? Have you seen any evidence of water carrying away soil?

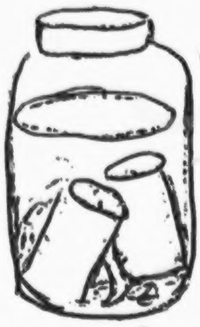
Detergents and Pollution

7. A. Place detergent in water. Allow soapy water to stand. Stir at intervals.

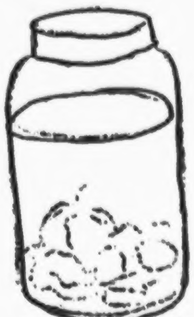


Helpful hints: Is detergent ever used up? What happens to detergents that are returned to our streams?

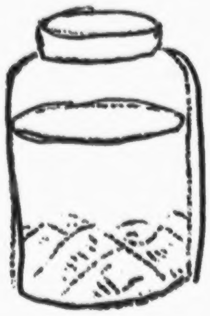
B. Assemble several test jars. Fill with water and add different types of refuse commonly tossed into streams and lakes. Leave in jars for a week. Check for color and odor at the end of this time. Place a piece of aquarium moss in each jar. How does contamination of water affect life in streams.



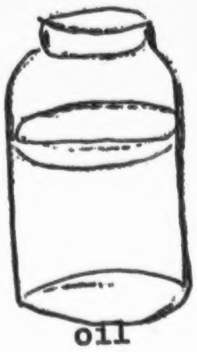
metal



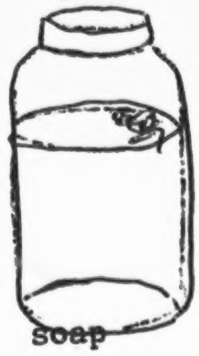
discarded food



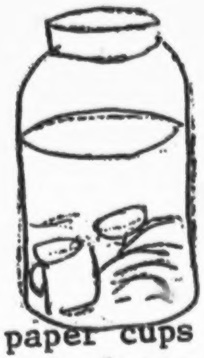
newspaper



oil



soap



paper cups and plates

Helpful hints: Children may suggest other types of contamination that may occur in nearby streams. Discussion should include other relationships such as the effect on fish that would feed on the plants, insects whose life cycle begins in the water (mayflies, caddis flies, etc.) birds who eat fish or insects along streams, animals and plants living along riverbanks, animals that come to the stream to drink, animals that spend part of their time in the water (beavers, muskrats, turtles, frogs, others), animals that eat fish or mussels from water (raccoons, bears, humans).

Is Your Water Contaminated?

8. (Detection test for detergent and other organic material) Fill a tall cylindrical bottle, similar to that used for olives, half full with a water sample. The bottle is stoppered and is shaken. High amounts of detergents in the water will cause a noticeable foam. Small amounts to not foam. Instead a thin film forms and travels upward on the side of the glass bottle. "The film rises until it disappears at the height dependent on the contamination in the water." The greater the height, the greater the contamination. No rings form with distilled waters or most well waters that are relatively free from contamination.

Helpful hints: With most surface wells and surface waters, positive ring values are obtained. A ring measuring 3/8" to 1/2" indicates 0.3 to 3/million of detergent in water.

Field Trips

1. Ask an employee of the water company to visit class. Make a list of questions the class wishes to ask him before he comes.

   Suggested questions include:

   (1) Where does our water come from?
   (2) How much water does our city need?
   (3) How is our water purified?

2. Secure permission to take a field trip to the water company.

3. Take a field trip to observe evidence of the destructive work of water. Look for: denuded construction sites, bore cuts and fills, eroding ditches and stream banks, gullying along hills.

SUGGESTED VISUAL AIDS

Films

Adventures of Junior Raindrop, 8 min., color, USDA.

Ground Water, 11 min., EBF.

Mountain Water, 18 min., color, USDA.

A Visit to the Waterworks, 10 min., color, EBF.

Water and What It Does, 11 min., color, EBF.

Water Cycle, 10 min., EBF.

Water for the Community, 11 min., COR.

Water in the Air, 11 min., EBF.

Water, Water Everywhere, 10 min., color, COR.

Waters from the Mountain, 20 min., color, USDA.

Watershed Wildfire, 21 min., color, USDA.

Your Friend the Water, 6 min., color, EBF.

Transparencies

Our Water Resources, 3M.

Film Loops

Everglade Swamps, Super 8 mm, Ealing.

Flash Flood, Super 8 mm, Ealing.

Mountain Storm, Super 8 mm, Ealing.

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC -	Film Associates of California 11014 Santa Monica Boulevard Los Angeles, California 90025
IFB -	International Film Bureau, Inc. 332 South Michigan Avenue Chicago, Illinois 60604
KAB -	Keep America Beautiful, Inc. 99 Park Avenue New York, N. Y. 10000
KSC -	Kaiser Steel Corp. Kaiser Center 300 Lakeside Drive Oakland, California 94600
MH -	See McGraw-Hill Book Company
MHB -	McGraw-Hill Book Company Film Department 330 West 42nd Street New York, N. Y. 10018
3M -	3M Company Visual Products Division Building 220-10 E 2501 Hudson Road St. Paul, Minnesota 55119
MTP -	Modern Talking Picture Service 1212 Avenue of the Americas New York, N. Y. 10036
NAS -	National Audubon Society 1130 Fifth Avenue New York, N. Y. 10028
NGF -	Nature Guide Films 64 East Vende Road Bountiful, Utah 84010
NYAP -	New York State Air Pollution Control Board 84 Holland Avenue Albany, New York 12208
PD -	Pat Dowling Productions 1056 South Robertson Boulevard Los Angeles, California 90000
RWP -	Roy Wilcox Productions Allen Hill Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

Director, Information Division
Soil Conservation Service
U. S. Department of Agriculture
Washington, D. C. 20250

Director, Division of Information and Education
U. S. Forest Service
U. S. Department of Agriculture
Washington, D. C. 20250

Chief, Division of Information and Education
U. S. Forest Service, Region 2
Federal Center, Building 85
Denver, Colorado 80225

Chief, Division of Information and Education
U. S. Forest Service, Region 4
Forest Service Building
Ogden, Utah 84403

Chief, Division of Information and Education
U. S. Army Corps of Engineers
U. S. Department of Defense
Washington, D. C. 20315

Chief, Information Branch
Division of Water Supply and Pollution Control
Public Health Service
U. S. Department of Health, Education and Welfare
Washington, D. C. 20201

Chief, Division of Information and Education
Bureau of Reclamation
U. S. Department of Interior
Washington, D. C. 20240

Regional Director
U.S. Bureau of Reclamation
Federal Center, Building 46
Denver, Colorado 80225

Regional Director
U. S. Bureau of Reclamation
P. O. Box 2553
Billings, Montana 59101

WATER

Regional Director
U. S. Bureau of Reclamation
P. O. Box 360
Salt Lake City, Utah 84110

Information Officer
Geological Survey
U. S. Department of Interior
Washington, D. C. 20242

Director of Information
Tennessee Valley Authority
New Sprankle Building
Knoxville, Tennessee 37900

National Association of Soil and Water Conservation Districts
Suite 1105
1025 Vermont Avenue, N. W.
Washington, D. C. 20005

Director of Education
The Conservation Foundation
1250 Connecticut Avenue
Washington, D. C. 20036

Conservation Chairman
The Garden Club of America
598 Madison Avenue
New York, New York 10022

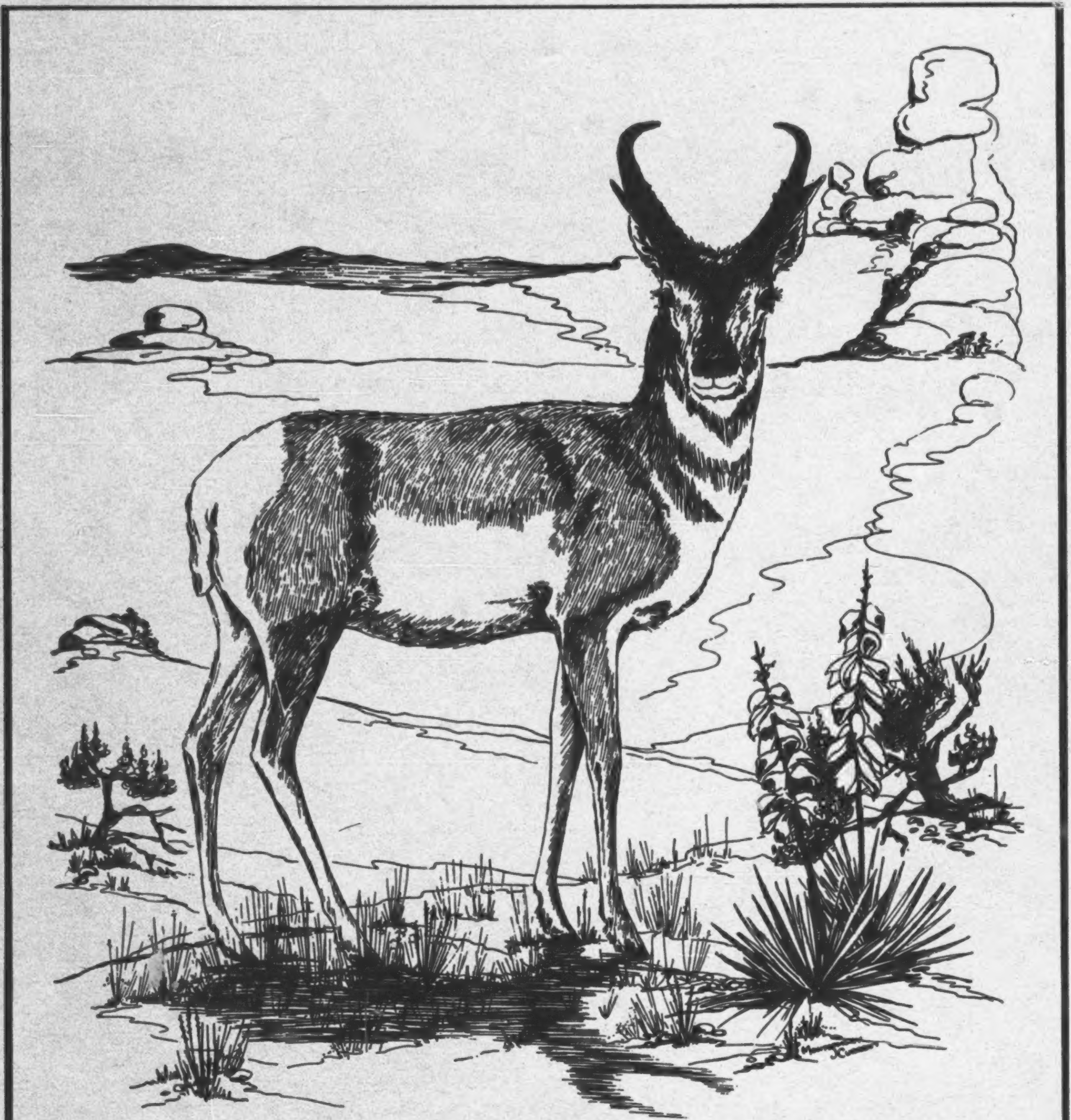
Director of Information
The Izaak Walton League of America
1326 Waukegan Road
Glenview, Illinois 60005

Director of Education
National Audubon Society
1130 Fifth Avenue
New York, New York 10028

Chief, Conservation Education Division
National Wildlife Federation
1412 Sixteenth Street, N. W.
Washington, D. C. 20036

State Engineer
Wyoming Engineer's Office
State Office Building
Cheyenne, Wyoming 82001

CONSERVATION EDUCATION IMPROVEMENT PROJECT



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UNIVERSITY OF WYOMING

College of Education

SOIL: FOUNDATION OF LIFE

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SOIL: FOUNDATION OF LIFE

TEACHER'S DISCUSSION

In light of expanding human populations and decreasing arable acres, the importance of good soil management and improved crop yields becomes immediately apparent. It should be pointed out in the introductory discussion with the pupils that land, in order to be useful for food production, must be cleared and cultivated. Food and fiber are the necessities of life. However, the cultivation process, though necessary, harbors the potential for land destruction.

arable: land fit for cultivation

Agricultural history of the older civilizations indicates people first settled in low lands to labor in agricultural pursuits. If farming was found on the mountain slopes, terracing practices were of necessity followed. After centuries of development of civilization, 75 percent of the earth's inhabitants are still found on the flood plains and low lands. Large populations aggregate in cities now located on these once farmable areas. As cities develop and roadways expand, more land is taken out of production.

terracing: ridging land on a contour line

Complexity of Soil

Soil is a natural collection of assorted particles of rock of various sizes and shapes. Numerous minerals, water and atmospheric gases, decomposing organic remains of plants and animals, together with microorganisms too small to see with the unaided eye, and a host of plant roots and many other types of small animals are also part of the soil. This body of soil is dynamic or changing. The interaction of its components causes chemical and physical processes that aid and assist in the development of characteristics unique to that soil. Further, water, wind, and glacial ice have built up the soil and worn it down in the process of soil development. In fact, if we examine all the factors affecting soil development, they could be arranged into five categories: climate, topography, organisms, parent rock material, and time.

Climate

The average weather conditions in a region over a series of years is climate. Climatic conditions are a composite of humidity, cloud cover, light duration, temperature, atmospheric pressure, precipitation, and winds. Two of these factors, precipitation and temperature, are most significant in soil formation.

Precipitation: Of the precipitation occurring in a region only about 15 to 20 percent actually reaches the ground water. Some of the moisture is lost prior to reaching the ground due to evaporation during the actual descent and interception by foliage. Another portion is lost through surface run-off into streams and ponds; however, that water which actually enters the ground is most effective in soil development. Some of the factors influencing effective precipitation include the slope of the land (steeper the slope the less the water penetration), duration and intensity of the precipitation, the relative humidity, vegetative cover on the soil, air and ground temperature, wind, and the soil texture. The water entering the soil gradually percolates downward dissolving minerals and organic nutrients to either redistribute them in lower soil layers or completely remove the dissolved materials from the productive soil areas.

soil texture: the coarseness of the soil as determined by the ratio of sand and clay comprising the soil

Temperature: The average yearly temperature greatly influences the overall chemical activity occurring in the soil. Generally, chemical reactions which occur in the soil increase in rate by two or three times with every 10°C (18°F) rise in temperature. Therefore, soil formation is more rapid in the warmer climates than in the cooler climates.

The surface features of the land essentially govern rates of erosion and the amount of water reaching through the soil profile. Also, surface temperature effects are largely regulated by topography; for example, the southern slope of a hill allows the sun's rays to be oriented at an angle which permits a more direct heating effect to the soil surface. The result is a warmer, drier soil subject to greater fluctuations in moisture and temperature than is found on similar slopes with northern exposures. The northern slope is cooler, more moist, and has less difference between extremes.

A slope of 5° toward the pole has nearly the same temperature as a region 300 miles of latitude away in the same direction. In addition, temperature generally decreases 3°C (5.4°F) for each 1,000 feet gain in altitude. Therefore, altitude also plays an important part in affecting the annual temperature of the soil and further modifies the local climate.

Organisms

The major forces responsible for the breakdown and resynthesis of mineral and organic constituents of the soil are biochemical in nature. These changes are induced by various organisms which inhabit the soil. For the

resynthesis: the formation of minerals and organic material into a combination of soil constituents characteristic of that soil purpose of a general discussion, soil organisms may be divided into microorganisms and macrooganisms.

Microorganisms: These include bacteria, fungi, algae, protozoa, nematodes (round worms), and rotifers. Nematodes, protozoa, and rotifers primarily assist in mixing soil and decomposing organic matter; however, many species of nematodes are harmful parasites living on plant roots.

Bacteria are especially important in the soil because of the role they play in decomposing organic matter. Some special types of bacteria fix nitrogen from the soil atmosphere into a usable form for plants while others assist in reducing sulfur and iron to a usable form. Generally, for each such chemical transformation of mineral nutrients, a specific bacteria is required. Fungi (yeast, molds, and mushrooms) and actinomycetes bacteria are also responsible for the breakdown of organic matter.

It should be mentioned that these microorganisms do not tolerate high acidic or basic conditions in their environment. Consequently, their influence in highly acidic or basic soils is greatly reduced. Like macro plants and animals, they too require favorable conditions of aeration, moisture and temperature for optimum growth and activity.

Macroorganisms: Large plants transfer nutrients from lower to higher levels of the profile. For example, greasewood and saltbush, absorb sodium in their roots and move it upward through the plant into leaves. Subsequently, the leaves drop to the ground, thereby concentrating the sodium on the surface beneath the plant. The accumulation of sodium results in a higher soil pH beneath the plant than in adjacent soil. Locoweed and lupine are plants which take up selenium, a mineral that can be harmful to grazing animals.

pH: the pH ranges are between 0 and 14, a pH 7 being neutral; a pH above 7 is associated with basic conditions, below 7, with acidic conditions

Other effects on soil development contributed by these larger plant groups are reduction of wind velocity over the soil surface thus reducing evaporation loss and wind erosion, reducing soil temperature, and increasing the relative humidity of the soil atmosphere. Still other effects include increased interception of falling moisture and transpiration of moisture by the plant which further reduces the volume of soil water. Larger plants also contribute much of the organic matter which the microorganisms use in sustaining themselves and which, when decomposed, are a source of available nutrients for subsequent plant needs.

Burrowing animals contribute to soil development by mixing the soil. Earthworms, rodents, etc., promote soil aeration, assist in formation of good soil structure, and increase the general fertility level of the soils they inhabit. Man further modifies the soil he uses through cultivation, irrigation, and fertilization.

Parent Material

The original rock material from which the soil is ultimately derived is referred to as parent material. Young soils exhibit many of the characteristics of the material from which they were developed, such as color, texture, and composition. As the soil becomes more mature it resembles the parent material less, especially where leaching of the soil materials has been great.

leaching: dissolving out by water percolation through the soils

In general, where granite is predominate, sandy soils with good physical conditions develop. In areas composed chiefly of basalts and gabbros, soils tend to be more fertile, contain more potassium and phosphorus, and are finer textured. These soils frequently have drainage problems. The productivity of soils formed from limestone is dependent upon the impurities contained in the limestone, especially in humid climates. The calcium carbonate leaches out and the impurities remain behind to form the soil. Shales develop a fine-textured soil and may have high quantities of soluble salts. Sandstones and conglomerates form sandy light-textured soils which possess good drainage and water movement.

Time

Time is required for soil to develop, but time, as such, is considered to be a passive factor in soil genesis. Soil maturity is the result of the interaction of the five factors mentioned. Soil development proceeds at a more rapid rate under humid-temperate climates than in cool dry areas.

passive: non-acting

soil genesis: origin or formation of the soil

Soil Classification

The development of a soil classification scheme has been evolving for many years. The most recent attempts involve a technical approach beyond the scope of this work. Basic to the new shceme, however, is an attempt to effect a more quantitative definition of soil categories. The definitions of the categories are expressed in the properties of the soil which can be observed or measured. A basic assumption is that soil is continuous on the land surface and can be classified into subgroups in various ways. The general purpose of the scheme is to assist in bringing out relationships among the soils themselves and between the soils and the other elements of their environment.

Plant Nutrition and Soil

Plant nutrition is dependent upon the physical, chemical, and biological soil characteristics which govern the availability of minerals as plant nutrients.

There are 16 basic minerals needed for good plant nutrition. A host of other minerals are also present in plants, but their need is not completely understood. Among the 16 basic minerals are the fertilizer elements: nitrogen, potassium, and phosphorus. Soils may possess large amounts of nutrients, but the nutrients may be in a form which will not permit their use by growing plants. These minerals come from such sources as parent rock material, organic matter, water, and the atmosphere. Minerals are eventually removed by various processes from the original source of origin and are placed in an available form for plant use. Nitrogen, for example, is released by microorganisms through the decay of organic material, usually from a protein source. Half of the available phosphorus comes from decomposition of organic matter. The availability of nutrients of growing plants can be greatly altered if the reaction (pH) of the soil is extremely high or low.

Under acid conditions, calcium, potassium, and magnesium are sufficiently soluble to be leached from the soil by the downward movement of the soil water. Furthermore, under such conditions, iron, aluminum, and manganese may be soluble to such an extent as to create toxic conditions for plant growth. However, under these same conditions, the solubility of phosphate is greatly reduced, rendering it less available for plant use. Also, if the soil is acid enough the nitrogen-fixing bacteria cease to function and the breakdown of organic matter slows, further reducing the availability of plant nutrients.

Under basic conditions, iron, zinc, and manganese become unavailable as they precipitate into a solid form. At high pH, the availability of phosphate is greatly reduced because of the formation of insoluble calcium phosphates. If the soil is of an extremely basic nature, sodium is present. When sodium is in the soil, the soil particles tend to disperse destroying any soil structure that might be present. Plant root destruction is also apparent. Soil organisms tend to cease their function under such high basic conditions.

Therefore, soils are most productive when their reaction is near neutral.

Safeguarding Soils

Erosion may be divided into geological or normal and accelerated patterns. The normal geologic process or erosion accounts for the leveling of mountains, the building of plains, plateaus, terraces, valleys, and alluvial fans. It proceeds so slowly that the processes of soil formation keep pace with the destructive forces. When the destructive forces of erosion exceed the natural rate of weathering it is called accelerated erosion. Accelerated erosion is principally a result of man's influence upon his environment. In man's quest to provide for his needs, a certain amount of accelerated erosinn will occur. Erosion is greatly increased as a result of the unnecessary removal of vegetative cover, improper cultivation methods for a particular area or soil condition, and improper application of water to the soil surface. It is estimated that 75 percent of the farm land of this country is now eroding faster than soil is being formed as a result of man's mismanagement of the land.

alluvial: soil, sand or gravel deposited by water

Water Erosion

Safeguarding the soils on slopes where water can cause difficulty is one of the major objectives of soil conservation practices. Such practices attempt to increase the water absorption capacity of the soil by decreasing run-off. Some of these practices are strip-cropping, contour farming, soil improvement, crop rotations and retention of crop litter at the surface, namely, stubble mulching. Other practices are established to direct excess run-off into broad base terraces, outlet channels, natural drainage channels and pondments.

Gullying and rill erosion are the usual manifestations of troubled land. Rills, then gullies, develop as the water with its load courses down the slope seeking channels of escape. Sheetwash, another form of water erosion, is not as noticeable since the soil particles are removed rather uniformly from the entire slope and floated downward during heavy precipitation.

Wind Erosion

Wind erosion is generally restricted to arid and semi-arid grasslands and deserts. Sloping land as well as level land can be affected. The fine soil particles are lifted into the air leaving only coarse material behind. The wind has a drying characteristic which aids the lifting process. Particles moved by the wind may bounce along the surface of the earth or be carried aloft to be held in suspension for days.

Such wind-born materials may be transported hundreds of miles from their point of origin. The great loessial deposits in the Mississippi, Ohio, and Missouri valleys are examples of wind-blown deposits.

loessial deposits: unstratified deposits of yellowish-brown loam deposited by wind action

Wind erosion of the great plains in recent years has caused extensive damage. Practices are used in curbing excessive wind erosion such as strip shelter belts, leaving crop litter on the surface, plowing cross wind, and rotating crops according to the moisture supplies of the soil.

Summary

Soils are natural, dynamic bodies covering the surface of the earth, each with a unique morphology as a result of a distinct combination of climate, living matter, parent rock materials, topography and time.

morphology: form and structure

The upper portion of the soil termed topsoil, is the portion most important to plant growth. It is this section of the profile that determines the fertility of the soil. It can be compared to the cream on a bottle of milk. Consequently, it is the aim of the soil conservationist to devise and promote practices that will prevent the loss of this valuable natural resource.

Suggested References

Teacher's Reading References

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Highsmith, R. M., J. G. Jensen and R. D. Rudd. 1962. Conservation in the United States. Rand McNally & Co., Chicago.

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United States Department of Agriculture. 1958. Soils: the 1957 Yearbook of Agriculture. Washington, D. C.

RESOURCE UNIT

Soils

Time Allotted _______

Unit Objectives

1. To illustrate the importance of soils
2. To emphasize the need to care for soils

Concepts

1. Most plants require fertile soil and support to grow
2. Soil is made of different materials
3. Not all soils are alike in their ability to grow plants
4. Holding the soil in place is essential for continued plant and animal production

Activities

Demonstrations and Investigations

- a. Plants and supports
- b. What's in soil
- c. Poor soil and plant growth
- d. Living topsoil
- e. Windbreaks and shelter belts
- f. Clear water contains plant food
- g. Effects of contouring
- h. How much water is in the soil?

SOIL: FOUNDATION OF LIFE

Outline	Activities
I. Importance of Soil to Mankind	
A. Soil grows the plants we need for food	Film: Birth of the Soil
B. Soil grows the plant fibers for much of our clothing	
C. Soil grows trees for lumber	Film: Exploring the Farmland
D. Soil grows plants which support all animal life directly or indirectly	
II. The Formation of Soil	
A. Soils are made of mixtures of various rock particles and organic material 1. Large rocks fragment upon weathering into smaller particles 2. Basic rock types 3. Rock-plant relationships required for developing soil 4. Climatic factors affecting soil formation	Activity: What's in soil
B. Animal life and microorganisms in the soil have effect on plant production 1. Production of nitrogen 2. Production of carbon dioxide	
III. Soils are not alike in their ability to grow plants	Activity: Poor soil and plant growth
A. Soils may be too acid or alkaline	
B. Soils may have wrong kinds of minerals	
C. Soils may lack elements important to plant production	
D. Soil structure may be poor	
E. Topography influences soil formation and growing ability of soil	

IV. Soil May be Damaged Through Improper Use

- A. Improper cover removal may produce erosion of topsoil
    1. Fires
    2. Spraying
    3. Plowing
    4. Harvesting incorrectly

V. Soils Can be Protected to Maintain Their Productivity

- A. Land capability defines best use
- B. Protective measures
    1. Rotation
    2. Grassed waterways
    3. Contouring
    4. Terracing
    5. Stripcrops
    6. Fertilization
- C. Reclamation measures
    1. Reseeding
    2. Reforestation
    3. Gully control
        - a. Check dams
    4. Fertilization and mineral treatments

Activity: Windbreaks and shelter belts
Film: Adventures of Junior Raindrop

EQUIPMENT LIST FOR SUGGESTED ACTIVITIES

Gallon jar

Petri dishes, shallow bowls or saucers

Saran wrap

Paper towels

Seeds: bean, radish, oats, grass, others

Quart jar -- 1

Gauze or small piece of screen

Tape or rubber bands

Several sizes of boxes or planting flats

Flower pots or cans

Hand lenses or magnifying lenses of some type (lenses from old flashlights will do)

Paper cup

Borrowed electric fan or reversible vacuum cleaner

Access to oven

Flat pan

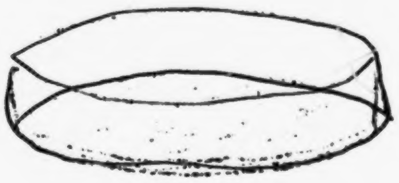
Coffee can with holes in the bottom

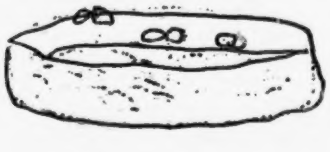
SUGGESTED ACTIVITIES

Demonstrations and Investigations

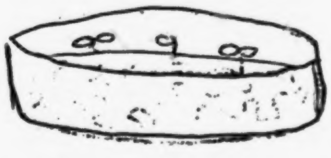
Plants and Supports

1. Cut four layers of paper toweling to fit the bottom of several small dishes. Moisten the paper toweling in each dish. Let the children place radish seeds in each dish. Cover the dishes with saran wrap to prevent evaporation of moisture. Place dishes in a window. Observe several days

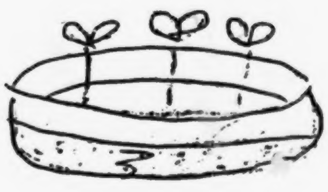




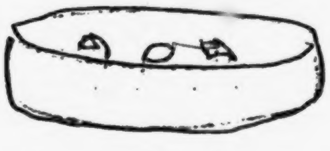
styrefoam



paper towel



soil



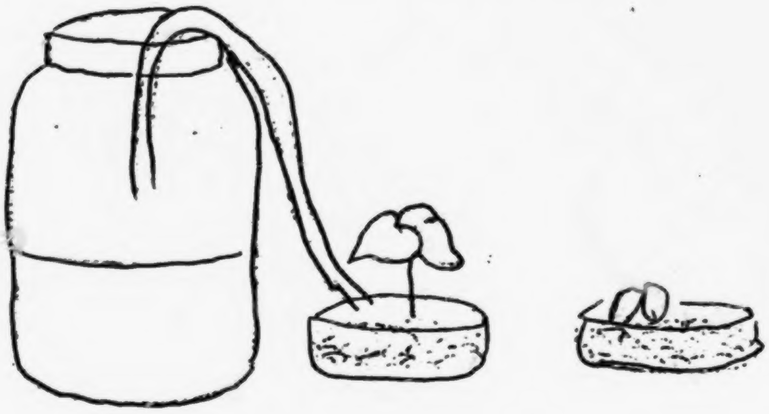
sawdust

Helpful hints: When seeds sprout, discuss the appearance of the seedlings with the children. Ask why the seedlings do not stand erect. Allow the children to suggest several substances that might hold the plants erect. The children will probably suggest soil immediately. The teacher can ask for other substances: sawdust, more paper towels, styrefoam. Remove the saran wrap and try each of these things. Encourage the children to observe the plants each day. Add some water each day but be careful not to drown the plants. When it becomes obvious that only the plants in the soil are thriving, ask the children what plants must get from soil besides support. Other substances support the seedlings, but only the seedlings in soil are growing well.

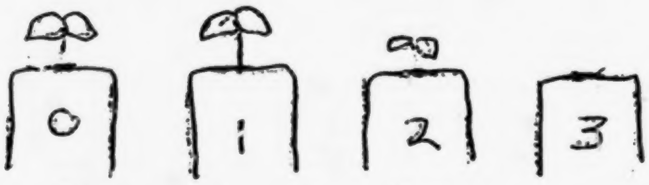
What is in Soil?

2. A. Fill a gallon jar half full of good garden soil. Fill with water. Stir and then allow to settle until water is completely clear. Plant seeds in two dishes of styrefoam. Water one dish with water siphoned from the top of the jar containing soil. Water the other dish with distilled water. Set this aside and proceed on the next part.

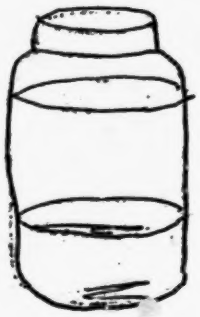
Helpful hints: When several days have passed, ask which group of plants grows the best. Can clear water carry food to the plants from the soil? Ask children if their parents use any kind of fertilizer at home for their yards or gardens. Ask if any would like to bring a sample of these plant foods.



Compare the way the plants grow in plain soil and in fertilized soil. Compare the way plants grow when you use the recommended amount, twice the recommended amount, and three times the recommended amount.

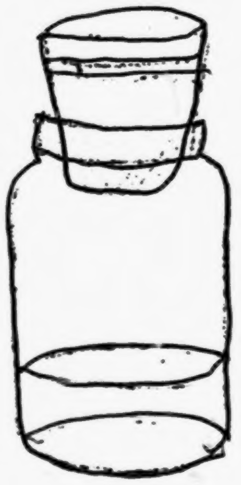


B. Place a cup of soil into a quart jar. Fill the jar 3/4 full of water. Cap the jar tightly and shake it. Shake until all lumps are dissolved. Allow the jar to stand overnight. Proceed to 2C and set this up also for the next day.



Helpful hints: Why did the soil in the jar divide itself into layers? Do different things in the soil weigh different amounts? What would you expect to be at the bottom of the jar? (rocks and sand). What is floating on the top?

C. Make a trap to catch anything in the soil that is alive. Cut the bottom out of a paper cup. Tape a piece of gauze or screen wire across the bottom of the cup. Put soil in the cup. Put saran wrap over the top of the cup. Put a rubber band around the saran wrap. Set the cup into a glass that has a small amount of water or alcohol in the bottom. Put the glass in the window in the sunlight. Leave it overnight.

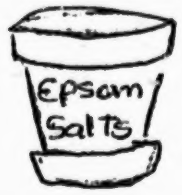


Helpful hint: Nothing can get out through the top of the cup. If there is anything alive in the soil, it will crawl out through the bottom. Be sure the cup fits into the glass tightly, but does not go down far enough to touch the liquid in the glass. Look the next morning to see if any small living things are in the liquid. Did anything get trapped in the liquid? Does the soil have anything alive in it?

D. Place a small pile of soil on a piece of paper at each child's desk. Give each child a hand lens or magnifying glass of some type. Ask them to examine the soil to see what soil is made from. Make a list on the board as each child discovers something. Suggested list includes: rocks, small rocks, roots, bits of leaves, pieces of dead insects, water, and sand.

Poor Soil and Plant Growth

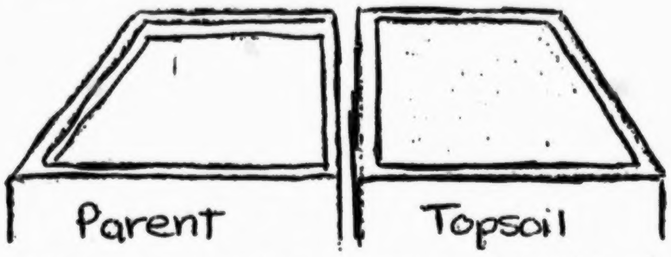
3. Place good garden soil in two pint containers. Mix about 1/8 of a cup of epsom salts with the soil in one of the containers. Plant seeds in both soils.



Helpful hints: If your area has alkali soil present, perhaps that soil could be used rather than the soil containing spsom salts.

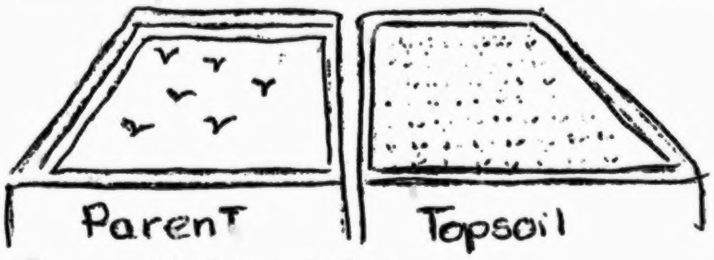
Living Topsoil

4. A. Place samples of topsoil and parent material in two shoe boxes lined with plastic sheeting. Smooth out each soil sample and water it enough to keep it moist but not wet. Keep the boxes near a window and watered for several days.



Helpful hints: Do you see any plants starting to grow? Do the results show that there is life in the topsoil and that there is no life in the parent material.

B. After two weeks, remove all the plants growing in either box. Stir the soil well, and plant bird seed, grass, wheat, etc. Again keep the boxes moist, warm and near a window.



Helpful hints: Grow the plants long enough to observe any differences in the health of the plants in the two boxes and compare them.

Windbreaks and Shelter Belts

5. A. Fill a flat or sand table with dry powdered soil. Secure a strong electric fan. A vacuum cleaner with a reversible hose can be used with good results. Bring from home a soft white cloth such as a dishtowel. Cut out miniature trees and shrubs from construction paper (make three sizes). Turn on the fan and move it to and from the box until it is about the right distance to make a little dust

storm. Shut off the fan and smooth the soil out again. Turn on the fan. Let it blow for a few minutes. Record the time the fan was on. Examine the cloth.

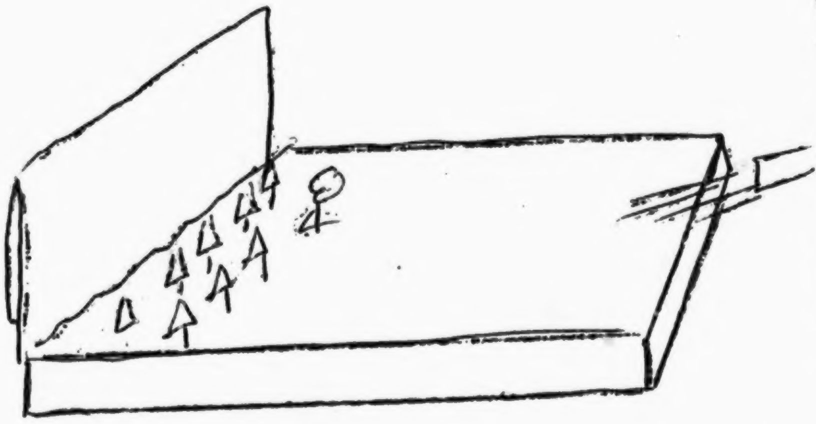
Helpful hints: Dirt on it indicates wind erosion. Now put up your "shelter belt" as illustrated.

B. Plant the trees with the flat side to the wind. Put them close enough in the row so the branches overlap a little. Hang another moist cloth and again turn on the fan. Let it run exactly the same length of time as before.

Helpful hints: Note the difference in the amount of soil blown into the cloth.

C. For a variation you may want to try this first with one, then three, then four rows of trees to find out how many rows it takes to really stop the wind.

Helpful hints: Most farm windbreaks have five or more rows of trees.



A more accurate measure of the wind erosion will be obtained if a large sheet of paper, freshly covered with a thin layer of Elmer's glue (dilute with water) be substituted for the piece of cloth.

Clear Water Contains Plant Food (Leaching Process)

6. Fill a deep container with topsoil (1 quart juice can). Fill the container to near the top with water. Let the water stand a day. Use this water to fertilize the growing plants in a poor soil. (Use sandy soil or sand for this.) Use tap water in one case and soil water in the other for a comparison.

Effects of Contouring

7. Set up two mounds of dirt. One furrowed up and down and the other across. The same amount of water is poured down the mounds and a comparison is made.

How Much Water Is in the Soil?

8. Oven dry soil for 24 hours. Weigh before and after drying.

Helpful hints: Discuss the importance of water in soil.

SUGGESTED VISUAL AIDS

Films

Adventures of Junior Raindrop, 8 min., color, USDA.

Birth of the Soil, 10 min., color, EBF.

Conserving Our Soil Today, 11 min., CON.

The Dirt Is Dying, 13 min.30 sec., color, USDA.

Dustbowl, 26 min., MH.

Exploring the Farmland, 13 min., color, RWP.

A Heritage We Guard, 30 min., USDA.

Keep Your Eye on the Soil, 20 min., DEERE.

Story of Soil, 11 min., color, COR.

Trees to Tame the Wind, 10 min., USDA.

What Is Soil, 10 min., EBF.

Your Friend the Soil, 7 min., color, EBF.

Transparencies

The Land That Supports Us, Cat. No. 851, 3M.

Our Soil Resource, Cat. No. 852, 3M.

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

Chief of Conservation
Agriculture Stabilization and Conservation Service
U.S. Department of Agriculture
Washington, D. C. 20250

Director, Information Division
Soil Conservation Service
U.S. Department of Agriculture
Washington, D. C. 20250

State Conservationist
U.S. Soil Conservation Service
P. O. Box 340
Casper, Wyoming 82602

Director of Information
Tennessee Valley Authority
New Sprankle Building
Knoxville, Tennessee 37900

Information Officer
Bureau of Indian Affairs
U.S. Department of Interior
Washington, D. C. 20240

Chief, Division of Information and Education
Bureau of Reclamation
U.S. Department of Interior
Washington, D. C. 20240

National Association of Soil and Water
Conservation Districts
Suite 1105
1025 Vermont Avenue, N. W.
Washington, D. C. 20005

Soil Conservation Society of America
7515 N.E. Ankeny Road
Ankeny, Iowa 50021

Conservation Chairman
The Garden Club of America
598 Madison Avenue
New York, New York 10022

Director of Education
The Conservation Foundation
1250 Connecticut Avenue
Washington, D. C. 20036

CONSERVATION EDUCATION IMPROVEMENT PROJECT

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UNIVERSITY OF WYOMING

College of Education

GRAZING LANDS

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GRAZING LANDS

TEACHER'S DISCUSSION

Grazing lands are very important for grazing livestock, as wildlife habitat, water production, outdoor recreation activities and aesthetic values. Dominant plant species characteristically subdivide grazing lands into grasslands, shrublands and open woodlots and forests.

Historically, wild animals grazed over vast areas of North America. The bison is probably the most famous. A vast natural grassland on the Great Plains supported unbelievable herds of these animals. Herds were so large they could cover 50 square miles of prairie at the same time; counts of 500,000 from one spot were not rare. To the Plains Indians the buffalo converted grass into meat to eat, produced skins for clothing and tepee coverings, furnished bone for tools, etc. Other grazing animals such as deer and elk provided similar materials for other Indian cultures. By 1876, ruthless exploitation of the buffalo for meat, hides, and bone, plus increasing settlement of the West and particularly the Great Plains, doomed the remaining bison to near extinction. While not as dramatic or as drastic, the reduction of other wild grazing animals followed a similar pattern.

The domestic conversion of United States grazing land plants to meat and other animal products began with the introduction of cattle, sheep and horses by the Spanish expedition commanded by Cortez early in the 16th century. In general, these domestic livestock prospered under the Spanish management and by the late 16th and early 17th centuries cattle and sheep grazing operations had spread to New Mexico and California.

The horses which escaped or were stolen from the Spanish by the Indians played an important role in the exploitation of the wild and domestic grazing animals. The Plains Indians were able to use the horses to conduct more successful buffalo hunts. They also used the horses to move their villages after the nomadic herds of buffalo rather than waiting for the buffalo herds to pass a permanent campsite.

The horse played an equally important role in herding of domestic livestock such as the cattle and sheep. On the large open rangelands of that time, the cattle particularly became very wild; not only were they hard to round up but a person was much safer on a horse than on foot.

Exploitation of Grazing Lands

The sheep and cattle industry had its origin in the Queces River south and east of San Antonio, Texas. A very favorable climate, abundant grass and water and freedom from attacks by the Plains Indians contributed to this region being called the "cradle of the livestock industry".

The lure of selling cattle costing $5 in Texas for $30 in the northern states started the formation of the now famous trail herds. The main objective was to trail the cattle to the nearest railroad facility for shipment to markets. Between 1866 and 1880, some 5 million cattle were driven north to such places as Abilene and Dodge City, Kansas. Despite these early large trail herd shipments, the number of cattle remaining in Texas was increasing. With the discovery that cattle could be raised on the northern and western ranges, these surplus Texas cattle were used to stock the rangelands formerly occupied by the buffalo. Between 1867 and 1880, large range operations were set up on the vast open and unfenced regions of the northern states. Two things were necessary for any degree of success, grass and water. On these open ranges one thing remained unchanged, the cattle. There were not high quality animals of great beef producing capability.

Cattle numbers continued to increase rapidly on western grazing lands until the middle 1880's. Severe winters in 1886 and 1887 coupled with extremely dry summers and overstocked ranges produced a catastrophic die-off of the cattle. Some outfits lost 90 percent of their stock. For example, the "Shoesole" outfit operating in the tristate area of Nevada, Idaho and Utah ran over 175,000 cattle in 1882. In 1885, they branded 38,000 calves. On the same range in 1891, they branded only 60 head of calves which represented the entire year's crop. Despite this tragedy, it is estimated that cattle numbers in the 17 western states had multiplied from 4 or 5 million in 1870 to over 26½ million in 1890.

Sheep followed the cattle movement to the open rangelands only after the cattle were well established. The sheep numbers increased during the same period that cattle numbers were declining. In Wyoming in 1886, estimates placed the sheep population at 309,000. This population grew until 2.6 million sheep were present in Wyoming by 1900.

Trailing large herds of sheep and cattle across rangelands and overstocking fenced pastures had a serious destructive effect on the nation's grazing resources. Numerous accounts of this damage have been written, but none are more typical than C. S. Walgamott's comments on the 1870 rangelands condition in Idaho and Utah.

> The condition of the range in the mountains was ideal, an over abundance of pure sparkling water flowing from many springs and creeks with virgin grass and vegetation in the mountain parks and coulees that yield two to three tons per acre if cut. Sagebrush was unknown in the mountains except on the low-dry ridges.

coulees: steep-walled vallies

The most severe grazing damage was done prior to 1920, but no accurate, quantitative measurement of this was made until 1936. At that time, U. S. Forest Service issued a report that 93 percent of the rangelands were deteriorating in one manner or another. Over one-half of these rangelands had less than half of the original grazing capacity. Some rangeland destruction was still occurring as late as 1930 when the western ranges were estimated to have a carrying capacity of 10.8 million animal units but had 17.3 million animal units grazing on them. During this time, the overgrazed land on the Wasatch Mountains in Utah produced floods which moved boulders weighing 200 tons into developed lands in Davis County.

animal unit: a statistical unit that is represented by the amount of feed required to sustain one mature horse or cow or any number of animals that will require that same equivalent amount

Several events began changing the dominant role of livestock on the western rangelands. The Federal Homestead Act of 1862 provided title to 160 acres of land without charge after the homesteader lived 5 years on the land. The acreage was eventually raised to a 640 acre limit per homesteader. Even 640 acres in the arid West was insufficient for raising enough cattle to make a living. Many ranchers had friends, relatives, and employees file on homesteads with the result that they were able to tie up most of the land adjacent to water, making it possible to control use of large areas of drier rangelands without owning the latter. This pattern of private land can still be seen in Wyoming if one looks at the Bureau of Land Management land status maps. The best rangelands along good water courses are predominantly in private ownership because of this early homesteading. Despite this, the many ranchers are still dependent on public domain for a large percentage of their grazing operations.

public domain: land owned by the government

The production of barbed wire in 1874 provided a means for restricting movements of the nomadic trail herds and trespass livestock, as well as keeping livestock out of croplands as farming invaded grasing lands. Barbed wire was frequently used to fence public as well as private lands. This divided livestockmen into the free grass group as opposed to those favoring fenced pastures. Both of these groups were united against the farmer who fenced his croplands.

Regulation of Grazing Lands

In 1905, the national forest administration came into being, and the first regulation of grazing activities on public domain began. Grazing of domestic livestock was considered a privilege, not a right, and the rancher grazed his livestock under a permit with a payment of grazing fees. The Forest Service restricts livestock grazing by limiting the number of animals allowed for grazing under each permit and by limiting the season when grazing will be permitted. This regulation was and still is considered by many stockmen to be unwarranted interference with their grazing activities.

Further governmental control and management of grazing on public domain was instituted with the passage of the Taylor Grazing Act in 1934 and the establishment of the Grazing Service. The Grazing Service was incorporated into the newly formed Bureau of Land Management in 1946. The latter now administers all of the unreserved public domain and the old Taylor Grazing district lands.

The reduction in number of cattle and sheep on public domain was drastic in some situations. However, those reductions were offset considerably by changes in the type of livestock used and certain management practices. Larger animals, such as the Hereford, replaced the rangy, lean Texas longhorn. Eighty percent or more of the Hereford cattle produced calves where 20 percent calving was average for the longhorn herds. Hereford calves average 400 pounds by the end of a summer, where the longhorn herd calves averaged 200 pounds. In addition, only cows and calves six months or over are presently counted under grazing permit on public domain. This means that a permit for 100 cows could allow 180 cattle to graze under that permit since 80 percent of the cows had calves 5 months old when they were counted onto the summer range. The same general situation applies to sheep.

The acres of rangeland available today are much less than they were in the 1880's and early 1900's because of increasing use of land for other purposes. Therefore, much of the grazing land today is able to produce as much, and in some cases, more pounds of meat per acre than in the late 1800's.

The shift to new breeds of livestock has required more intensive management and care on the part of the rancher, which means the establishment of operations to grow hay and other crops for winter feeding and even the development of irrigated pastures.

The dependence on native forage has further declined with feedlot operations in the cornbelt and grainbelt states. This has progressed to the point where young western range cattle are shipped to feedlots where they are fed corn and grain. Becoming fattened on these foods, they are then shipped to market. Much the same shift is taking place for sheep. A shift in emphasis from wool to mutton breeds is the result of increased farm ownership of sheep.

Damage to the grazing lands is not solely the result of domestic animal use and abuse. Wildlife must share some responsibility for detrimental grazing use. On the North Kaibab forest in northern Arizona, the deer herd was not managed and reached a population of 100,000 in 1924 on a range that should have supported only 12,000 to 18,000 deer. In Yellowstone National Park, a herd of elk was allowed to reach 15,000 animals on grazing lands that could only support 7,000 to 9,000 elk. Damage to vegetation and soil in both cases was severe and parts of those areas still show little change from the devastation years ago.

Grazing Lands of the United States

In the 48 contiguous states, 50 percent of the land area is used for grazing purposes. Of this 7 percent is cropland placed in pasturage, while 67 percent consists of grassland pasture and 26 percent consists of forest land used for pasture and range.

contiguous: touching or in continuous series

The various grazing lands in the United States may be grouped under three major types: grasslands, shrubs, and forests. Grasslands may further be subdivided into five distinct categories.

Tall grass prairie is located in the eastern Great Plains. Only 10 percent of the original acreage remains, the other 90 percent having been destroyed by plowing. These grasses exist under an annual precipitation of 20 to 40 inches. The average height of these grasses is 4 to 5 feet. The dominant species include the bluestems, dropseeds, switchgrass, porcupine grass, and wildrye. When in good condition the grazing potential is high. If left standing, the tall grasses do not cure very well. As a result, it is of little value for late fall and winter use. The grazing capacity requires 3/4 to 1 1/2 acres to supply an animal - unit - month of feed.

GRAZING LANDS

The coastal prairie is a strip 5 to 10 miles wide along the coastal areas of Texas and Louisiana. Generally, it is considered to be an extension of the tall grass prairie. Dominant grasses include bluestems, needlegrass, panicums, and Indian grass. The grazing capacity is very similar to the tall grass prairie.

The short grass prairie extends from the panhandle of Texas to the Canadian border, east of the Rocky Mountain foothills to the center of the Dakotas. It is one of the largest and most important grasslands in the United States. Average annual precipitation is 13 inches. The chief dominants include western wheatgrass, needle and thread, Junegrass, blue grama, and buffalo grass. These grasses cure on the stem in late summer and are highly nutritive during the winter. Grazing capacity varies between 2½ to 4 acres per animal - unit - month.

Semi-desert grasslands extend across the Southwest from central and southern Texas into Arizona. Precipitation is generally low but varies between 8 and 18 inches according to the elevation. Black grama, three-awn, and curly mesquite are dominant grasses at the higher elevations, while tobosa grass and alkali sacaton are dominant at the lower sites. This is one of the best year around grazing types because of good seasonal production and cured nutritive value. This type provides a typical grazing capacity of 6 to 7 acres per animal - unit - month.

Pacific bunch or Palouse grasslands extend from western Montana through to the Pacific Ocean. The greatest development of this type may be found on the Palouse prairie in eastern Washington. The chief dominant plant species are bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, western wheatgrass, big bluegrass, needle and thread, and June grass. Spring and fall grazing are the rule. Growth conditions generally require 4 to 6 acres per animal - unit - month.

The Pacific prairie is similar to but not quite the same as the Pacificbunch grasses. Essentially, this grazing type is found covering the foothills and central valley areas of California. The major dominant plants are purple needlegrass, wildrye, prairie Junegrass and melic grasses, plus annual grasses such as wild oats, cheat grass, red brome, etc.

The sagebrush-grass type is a component of the shrub type. The sagebrush type has actually increased, for as grass was thinned the sagebrush invaded the lands and became quite dense. Geographically this type extends from eastern Wyoming to northeastern California. This type is of major importance since it is essentially the prime or only area for spring and fall ranges. As a shrub type, the dominant species include big sagebrush, rabbitbrush and greasewood. The grasses are bluebunch wheatgrass, squirreltail, Indian rice grass, western wheatgrass, etc.

The salt desert shrub is found in southwestern Wyoming, western Colorado, and central Utah and Nevada. Annual precipitation is low and sources of water are frequently not dependable. As a sheep winter grazing area the dominant plants are spiny hopsage, winterfat, and black sagebrush. When not covered by snow, grass species of some importance are Indian ricegrass, sand dropseed, squirreltail, blue grama and saltgrass. The grazing capabilities average 18 to 20 per animal - unit - month.

The southern desert shrub grazing lands exist under severe growing conditions. Low and unpredictable amounts of rainfall together with high temperatures make the area practically a desert. Generally this type is confined to edges of Mohave Desert and along river courses of the Colorado, Gila, lower Rio Grande, and Pecos rivers. Use of this range generally is limited to those periods when annual grass production is high and water fairly abundant.

The forest types are some of the largest grazing types, but they represent some of the most abused. For example, the Pinon-Juniper, open forest type, extends from southwest Texas to central Oregon. Annual precipitation is less than 15 inches. The dominant shrubs are the mountain mahogany and cliffrose or bitterbrush and bluestem wheatgrasses. The carrying capacity is variable with 8 to 10 acres per animal - unit - month. The variety of forage available provides grazing for cattle, sheep, and especially good grazing for blacktailed deer.

The woodland chaparral is a grazing type peculiar to California. Essentially confined to the Central Valley and foothills of southern California, many shrub species form impenetrable brush thickets which are of little use to grazing but of considerable importance for watershed protection. Alfileria, slender oatgrass, and burr clover make it possible to develop grazing capacities of 2 to 3 acres per animal-unit - month on the lower slopes.

The second largest and most widely distributed grazing land type is the western open forest. Grazing lands here consist largely of high altitude meadows, open parks, and subalpine to alpine meadows. Forage consists of grasses, forbs, and shrubs growing beneath or near forest cover. Grazing seasons are very short and are confined largely to the summer months. Highly palatable and nutritious foods tend to offset the short grazing seasons. The open, park-like character of ponderosa forests make them very important grazing lands. The dominant species include serviceberry, snowberry, cliffrose, mountain mahogany, wheatgrasses, fescues, bluegrasses, needlegrasses, oatgrasses and sedges. Grazing capacity varies, but 6 to 10 acres per animal - unit - month is a general summer average.

In the open forests of the South, the grazing land is unique since most of it is privately owned. Annual precipitation is high with mild winters. This provides a long growing season. In this open forest type a generalization is not easily made since there are complex patterns of soil, soil moisture, hardwood-softwood mixtures and abandoned cultivated fields. The main forage species are: bluestems and broomsedge, dropseeds, panicums, Bermuda grass, wiregrass and switchcane.

Some comment should be made concerning intensively managed permanent pastures and cropland pastures. The permanent pastures in the North are predominantly of Kentucky bluegrass while in the South, Bermuda grass and Dallis grass are favored. The permanent pastures of the South, under intensive management have carrying capacities of one cow per acre for 9 to 10 months plus harvesting a ton of hay for feed during the non-growing period.

Cropland pastures are located on better soils, but are placed in pasturage in the interest of soil building, erosion and water control, and diversification of farm operations using livestock investments. There pastures usually are summer grazing units consisting of alfalfa, crimson clover, or grass mixtures. Sudangrass, soybeans, sorghums and oats provide good summer cropland pastures.

Range Management and Problems

Probably the most important concept to put across to students is the idea that every range has a carrying capacity. Each forage plant growing on the grazing land can stand to have only so much of its leaves and stems eaten. It must have some reserves left for normal growth needs, reproduction, and survival throughout the year. That amount of the plant growth produced over and above these minimal needs may be considered a surplus. It is this surplus that is available for consumption by animals. Carrying capacity can then be defined as that number of properly maintained animals which can be carried on a given grazing area without damaging the forage, causing erosion, or adversely affecting the area's water production. Carrying capacity will vary from very high on permanent pastures to very low on arid, rocky grazing lands.

Grazing land plants can usually be classified in one of three categories. Those plants which are nutritious and highly preferred by livestock but decrease in number with moderate grazing are known as decreasers. Those plants which are also nutritious and preferred but resist grazing use and increase in number or space occupied as decreasers diminish, are classified as increasers. Increasers are usually sod forming or sod holding plants which can be killed out under heavy grazing pressure. When increasers are destroyed by grazing, native or exotic weeds or woody plants having little nutritious value and little or no preference by livestock, replace them. These latter plants are designated invaders and contribute very little to holding soil or to the provision of forage. In the tall grass prairie, the big bluestem is a decreaser, the blue grama, an increaser, and the Russian thistle, an invader. Proper management of grazing land then works to balance the decreasers and increasers while holding invaders down to a minimum.

Future demands on grazing lands for watershed and recreation values need not be incompatible with grazing which is properly managed. All grazing land serves as part of many watersheds. Also, they contribute a major portion of the sediment in our western streams. The major job here is not greater production of water, rather it is to reduce the erosion and silt.

The low productivity of many grazing lands can be corrected frequently with range improvement techniques. Control of invaders by mechanical chopping, beating or mowing devices and chemical sprays may be effective. However, careful evaluation of the secondary effects on other values of the grazing lands such as water, wildlife, etc., are necessary.

Mechanical treatment of the land by contour furrowing, pitting, and water spreading to make more efficient use of the moisture should not be overlooked. Fertilization and reseeding may also be useful.

In every case of grazing land improvement, it must be pointed out that under no circumstances are these treatments any substitute for proper management of the grazing animals themselves.

Suggested References

Clawson, Marion. 1963. Land for Americans. Rand McNally & Co., Chicago.

Clawson, Marion and R. B. Held. 1957. The Federal Lands: Their Use and Management. Johns Hopkins Press, Baltimore.

Dasmann, R. F. 1959. Environmental Conservation. John Wiley and Sons, Inc., N. Y.

Foss, P. O. 1960. Politics and Grass - The Administration of Grazing on the Public Domain. Univ. of Wash. Press, Seattle.

Highsmith, R. M., J. G. Jensen and R. D. Rudd. 1962. Conservation in the United States. Rand McNally & Co., Chicago.

Smith, G. H., ed. 1965. Conservation of Natural Resources. John Wiley and Sons, Inc., N. Y.

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Webb, W. P. 1931. The Great Plains. Grosset & Dunlap, N. Y. Paperback.

RESOURCE UNIT

Grasslands

Time Allotted ________

Unit Objectives

1. To understand the relationship between soil, water, grassland and wildlife.
2. To understand man's need to control, preserve and restore grasslands and to learn some of the methods by which this may be accomplished.

Concepts

1. Grasslands are an important part of our nation.
2. Man has changed natural grasslands to meet his needs for croplands and for food for his animals.
3. Grasses help build and protect soil, prevent erosion and flooding, conserve moisture and supply nutrition for animals.
4. Grasslands can be damaged by misuses.
5. Man must exercise control over grasslands protecting them to insure continued productivity to meet his needs.

Activities

Demonstrations and Investigations

a) Types of Grasses
b) Grass Products
c) Use of Grass
d) Clip and Compare
e) Experiments with Local Grasses

Field Trips

Range observation

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. Man makes extensive use of grazing lands	
A. Not all grazing lands are grasslands	
1. Shrub types	
2. Forest types	
3. Grassland type	Activity: Types of grasses
a. Grasses cover one-fifth of earth's land area	
b. Grasses are used as a food crop by man and domestic animals	
c. Grasses are important in building and protecting the soil.	
d. Grassland areas relate to positions of oceans, mountains, and the prevailing winds. (Identify grasslands on world map or globe. Find latitude, altitude, average temperature, and rainfall of major grasslands.)	Film: National Grasslands
B. Some grazing lands have been made into cropland; others into rangelands for domestic use.	
1. Grazing lands in the past were not fenced or cultivated by man. Many areas still remain in the native state in Africa and Australia.	Field Trip: range observation
a. Many animals were dependent on grazing lands. (Ex. North American bison, deer, rabbits, prairie dogs, wolves, coyotes, snakes, hawks, etc.)	
2. Man utilized the vast plains and forest for domestic use.	
a. Plowed grasses and shrubs, disturbed forest areas to obtain cropland.	
b. Livestock were moved into the plains area.	
c. Regulations developed over rangeland use.	
(1) National Forest Service	
(2) Taylor Grazing and Bureau of Land Management.	

I. C. Management of Grazing Lands
- 1. Carrying capacity and limitations
  - a. Increasers, decreasers and invaders
  - b. Balance between wild animals and domestic animals on the same land
- 2. Erosional aspects and low productivity
  - a. Prevention methods
    - (1) Range rotation
    - (2) Seasonal use
    - (3) Restricting animal numbers
    - (4) Trampling to distribute seeds
  - b. Restoration methods
    - (1) Reseeding
    - (2) Pitting to conserve moisture
    - (3) Disuse of range
    - (4) Spraying against invaders

Activity: Clip and compare

Activity: Experiments with local grasses

EQUIPMENT LIST

2 Boxes 1' x 1' x 4" (Wood boxes are desirable but not necessary)

1 Electric fan

2 Metal pans or coffee cans

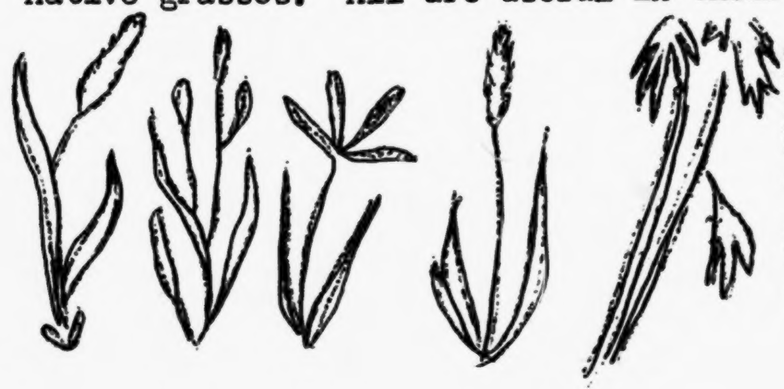
Coffee can with holes punched in bottom

SUGGESTED ACTIVITIES

Demonstrations and Investigations

Types of Grasses

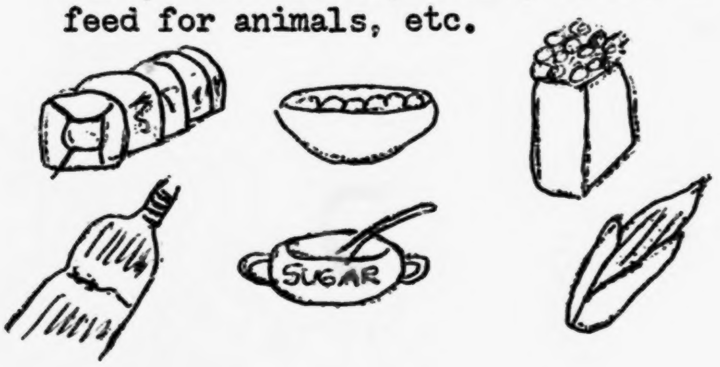
1. Make a collection of different types of grasses common to your locality. (Some of the grasses may be imported. Some may be native grasses. All are useful in their places.)



Helpful hints: Discuss what grasses are. Try to discover how grass helps in these different places. Why do some grasses grow better in certain places than others do? Relate to soil conditions.

Grass Products

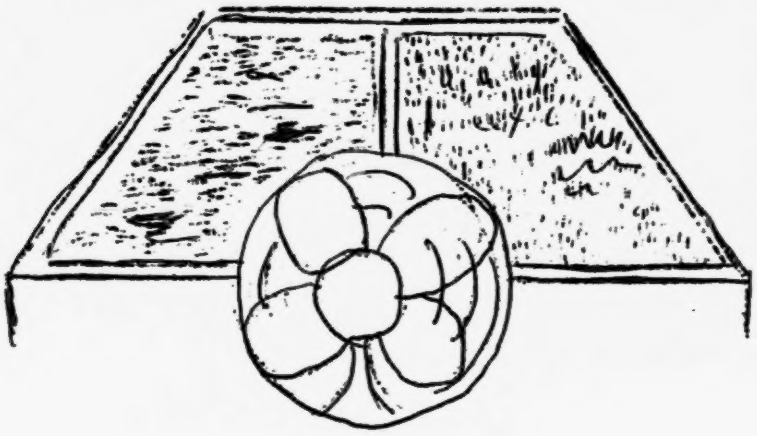
2. Make a collection of pictures of products man gets directly from grasses: rice, syrup, dry cereals, brooms, popcorn, sugar, all products of bamboo, oatmeal, all corn products: cornmeal, cornbreaad, karo, corn flakes, bread, cream of wheat, some types of paper, hay, feed for animals, etc.



Helpful hints: Discuss the importance of grass to man as a food for himself and for the animals he uses as food.

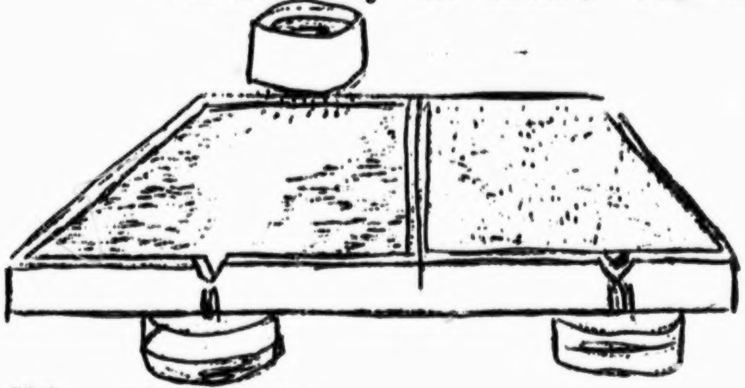
Use of Grass

3. A. Bring in a sod with grass and place in a box. Fill a similar box with loose dirt such as you would find in a plowed field. Allow both to dry out. When both are dry, expose the two boxes to a simulated wind. (An electric fan, a vacuum cleaner in reverse or a child blowing through a tube may be used.)



Helpful hints: Discuss how grass may protect soil in times of drought. Explain or allow a child to report on the dust storms in Oklahoma.

3. B. Pour water on both samples with a drip can. Saturate the soil in both boxes. Allow the water to overflow and collect in a container below. Observe the amount of soil carried from each container by the water. Use the same amount of water on each.



Helpful hints: Discuss the way grass may protect the soil from floods and heavy rains. Which box lost the most soil? How does grass protect soil from water erosion?

Clip and Compare

4. Set up two boxes with living grass sod. Water daily. Cut the grasses very short in one box. Continue to cut it short. Clip the grasses moderately in the other box. Observe the results.

Helpful hints: What does overgrazing do to grasslands? What will happen to soil on land that is overgrazed? Allow children to find out the amount of acreage needed for grazing animals in your state. Would the acreage be the same in all situations?

Invite the agricultural agent to come talk to the class about grasslands in your state. Prepare a list of questions to ask the agent before he comes. Examples:

(1) What kinds of grasses grow near our town?
(2) How are these grasses used?
(3) What things are dangerous to our grasslands?
(4) How can we help protect our grass?
(5) What practices does our state use to protect its grasslands?

Experiments with Local Grasses

5. Determine the type of soil in which local grass grows best.

Determine what type of local grass will best grow in a particular soil from your area.

Note: Additional experiments may be devised to suit the problems of your locality. If there is a boggy place where little vegetation occurs, the students might experiment to find a grass that would grow in

Note: (continued)
those conditions, duplicating in the classroom the amount of light and water and type of soil this location has available. Similarly, an arid area with an alkaline soil might be investigated. These would be true examples of research and might prove useful to the community.

Field Trip

1. Make a field trip to observe local practices in land management. Look for examples of good practices. Look for areas in which practices might be improved. Allow children to suggest methods of improvement.

SUGGESTED VISUAL AIDS

Films

Blades of Green, 15 min., color, UPR.

Blessings of Grass, 20 min., USDA.

Grass, the Big Story, 29½ min., color, USDA.

Grassland, 10 min., USDA.

Grasslands, 9 min., UWF.

The Grasslands, 17 min., color, EBF.

National Grasslands, 27 min., color, USDA.

Film Loop

Environments of the World (Super 8), Ealing.

Film Strip

The Grassland: Story of a Major Community, EBF.

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
105[illegible] Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

Director, Division of Information and Education
U. S. Forest Service
U. S. Department of Agriculture
Washington, D. C. 20250

Chief, Division of Information and Education
U. S. Forest Service, Region 2
Federal Center, Building 85
Denver, Colorado 80225

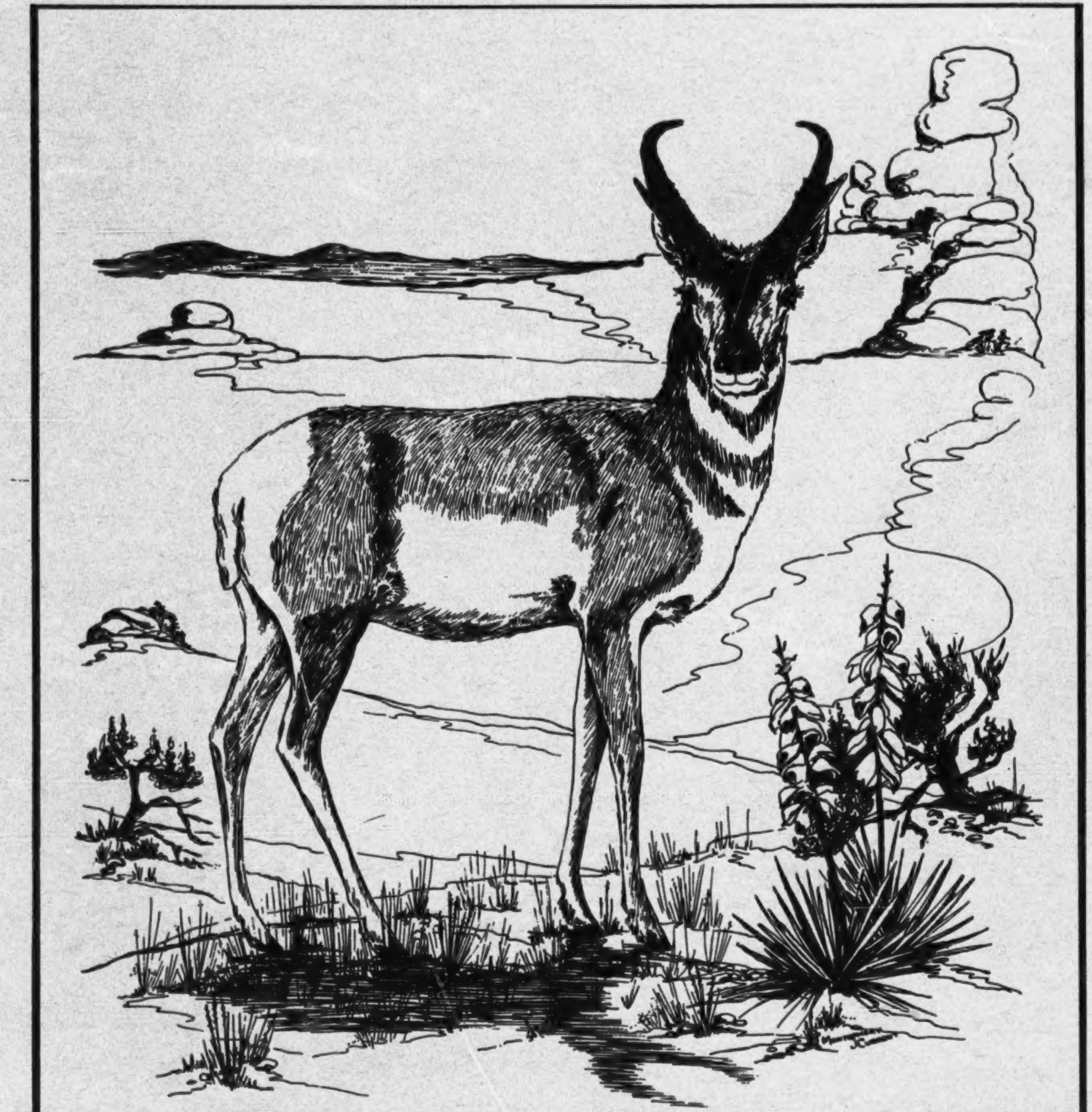
Chief, Division of Information and Education
U. S. Forest Service, Region 4
Forest Service Building
Ogden, Utah 84403

Information Officer
Bureau of Indian Affairs
U. S. Department of Interior
Washington, D. C. 20240

Information Officer
Bureau of Land Management
U. S. Department of Interior
Washington, D. C. 20240

State Director
U. S. Bureau of Land Management
2002 Capitol Avenue
Cheyenne, Wyoming 82001

CONSERVATION EDUCATION IMPROVEMENT PROJECT



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UNIVERSITY OF WYOMING
College of Education

FORESTS

TEACHER'S DISCUSSION

With 25 percent of the land area of the 48 contiguous states covered by commercially valuable forests, it may be difficult to have students appreciate that timber resources are being rapidly depleted. Since the time of the first white man's arrival, 15 percent of the United States commercial forest lands have been destroyed. These historical forest lands once covered 40 percent of the 48 states and produced nearly four times the timber volume we produce today.

contiguous: adjoining or adjacent

Wood Products Used By Man

In the industrialized countries of the world, the most important use of wood is lumber for construction material. The average American uses about 80 cubic feet of wood per year. This is about 2 times as much lumber as a Russian, 4 times as much as an Englishman, 6 times as much as a Frenchman, and 10 times as much as a Brazilian. Worldwide, the greatest use of forest products is for fuel. Over 50 percent of the total wood cut in the world is used as firewood. However, about 75 percent of the lumber used in the United States is now used for various types of construction such as housing, farm buildings, light manufacturing industry, warehouses, shopping center stores, schools, gymnasiums, garages, and churches (Fig. 1).

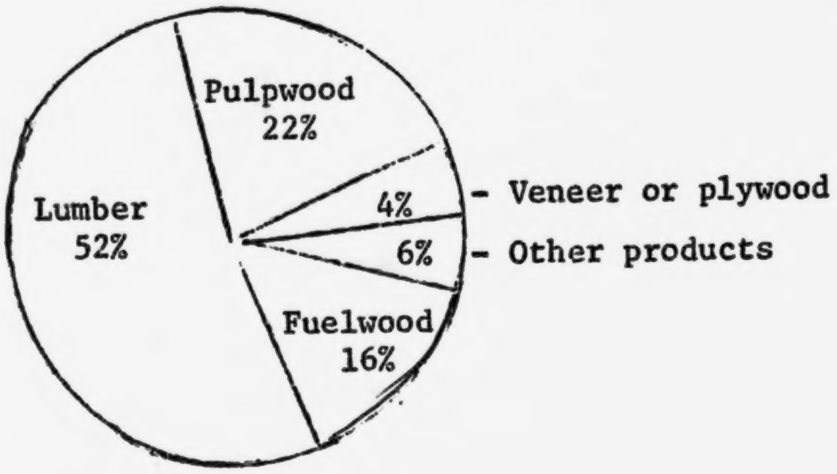


Fig. 1. Lumber Use in the United States

Other products using lesser amounts of lumber include: furniture, caskets and burial boxes, tool handles, household woodenware, novelties, radio and television cabinets, small boats and ships, agricultural implements, sports equipment, toys, musical instruments, ladders, signs, truck bodies and trailers, trunks, matches, nailed and wirebound boxes, cases and crates, dunnage in freight cars and ships, and pallets.

Increased use of pulpwood products in the United States has been phenomenal. During the 56 years from 1899 until 1955, paper products consumption increased 982 percent. To produce one Sunday issue of the New York Times requires 800 cords of pulpwood which represents the average harvest from 80 acres of pulpwood forests. Major paper products include newsprint; groundwood paper used for telephone directories, catalogues, wallpaper, ditto and mimeograph paper and scratch pads; book and fine papers used in magazines, books and stationary; coarse paper used for brown paper bags, wrapping paper, file folders, and electrical insulation; tissue and tiolet paper; building paper used for roofing felts, sheathing papers, felts for asphalt tile, automotive felts, and asbestos-filled paper. Other paper products include: container board used in packing boxes and corrugated material; bending board used largely for milk cartons, frozen foods containers, cereal boxes, toothpaste tube boxes; non-bending board used for shoe boxes, hat boxes, hard book covers, and filing case boxes; building board used for acoustical tile, and hardboards; and miscellaneous products which include paper tubes, drums and cans, egg cartons, cardboard, etc.

dunnage: loose lumber used around cargo to protect against shipment damage

pallet: a portable wood platform used for handling, storage or moving of material in warehouses factories, etc.

Increased woodpulp consumption is not only due to increased use of paper products but includes woodpulp use in manufacturing such products as rayon, cellophane, acetate plastics, photographic film, smokeless powder, telephone parts, tire cord, scotch tape, and plastic toys.

With the development of stronger, moisture-proof glues, the use of plywood and veneer products increased. Softwood plywoods are used for sheathing, subflooring, roofing, furniture, truck and trailer bodies, etc. Hardwood plywood and veneer products are used for interiors, paneling, cabinets and door construction, furniture, etc., wherever appearance, hardness and acoustical properties are important.

Increased use of electricity, gas, and oil for heating in the United States will further reduce the fuelwood consumption in the future.

Miscellaneous wood products include wood poles used for electric power, telephone and telegraph, piling and fence posts; railroad ties and mine timber; cooperage uses for tight or slack barrels and kegs; turned products such as spools and dowels; wood distillation products such as methyl alcohol, tanner's extract, turpentine and other naval stores; charcoal; shingles, etc.

Forest Lands of the United States

The 100th Meridian serves as an excellent dividing line for the forest lands found in the 48 continuous United States. The eastern half of the United States contains 75 percent of the total forest land which can be divided into four distinct forest regions: (1) Northern Forest, (2) Central Hardwoods Forest, (3) Southern Forest, and (4) Tropical Forest (Fig. 2). West of the 100th Meridian the remaining 25 percent of the forest land is divided into two forest regions: (1) Pacific Coast Forest, and (2) Rocky Mountain Forest. Within all of these forests, we can group the trees into softwoods or coniferous trees, and hardwoods or broadleaf trees.

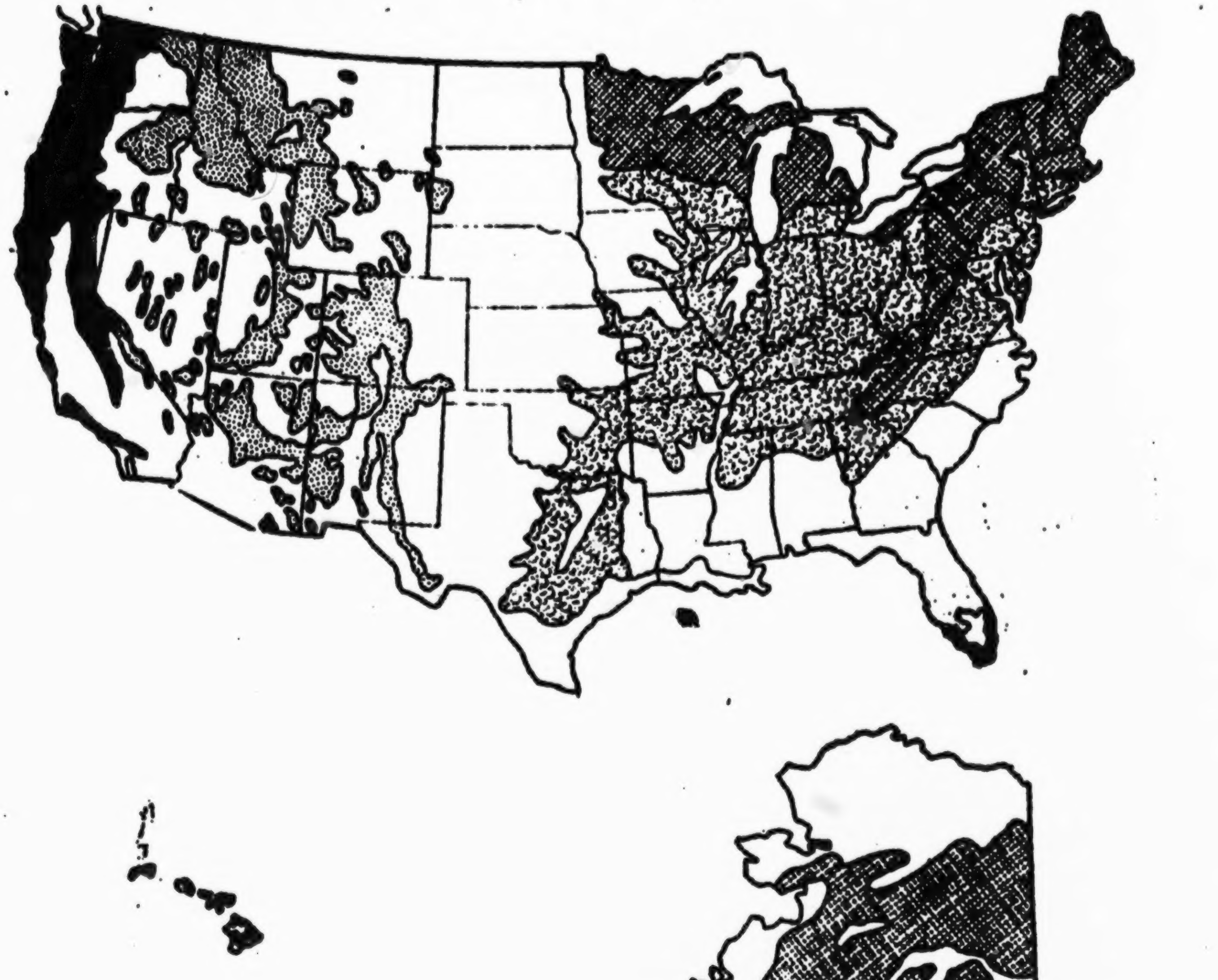
coniferous: trees bearing true cones and whose leaves are usually needle-shaped or scale-like evergreen structures

The Northern Forest is located on podzol soils which are quite acid. Precipitation ranges between 30 and 40 inches annually. The climate can be classes as severe with cold temperatures and a frost-free growing season extending at least 100 days. The northern portion of the forest is dominated by white and red pine in the Great Lakes region and spruce and fir in New York and Maine. In the southern half there is a transition forest consisting of birch-beech-maple-hemlock mixtures.

podzol: soils developed from generally sandy soild under cool wet climates; rainfall seeping through essentially forest litter forms humic acid, leaching out organic matter and iron and aluminum salts from the topsoil; the organic matter and salts are redeposited in the heavy clay subsoil

The Central Hardwood Forest consists chiefly of various combinations of oaks, hickories, beech, maple and elm, on gray-brown podzol soils which are quite fertile and not very acid. The climate is rather moderate with 30 to 60 inches of precipitation annually, and frost-free growing season of 100 to 200 days.

The Southern Forest is second only to the Pacific Forest as a tree growing area. The longleaf pine and slash pine are found along the coast on sandy, dry yellow soils of variable acidity and low fertility. The loblolly pine is generally found on wetter, yellow soils at lower elevations, while the shortleaf pine, being more tolerant of colder temperatures, is found inland at higher elevations on dryer, yellow soils. On the wet bottom land, where moderately fertile, neutral to basic red soils are found, the gums, oaks, hickories, and cypress grow. The climate is very warm and moist, with a frost-free growing season of 200 to 350 days, and an annual precipitation of 35 to 70 inches. Rapid tree growth is characteristic of this entire forest.



FOREST REGIONS

Rocky Mountain
Pacific Coast
Northern
Southern
Central Hardwood
Tropical
Nonforested
0
250
500
Scale in Miles

FIG. 2

The Tropical Forest is not important commercially since early exploitation removed the valuable mahogany and cypress trees. The only extensive remnants of these early forest species are now found on private reserves or in Everglades National Park. Tropical forests develop in hot, humid climates with 60 or more inches of precipitation annually. The soils are lateritic and quite acid.

laterite: soils developed under hot temperatures and high precipitation of tropics; extensive leaching and baking removes most of the nutrients and leaves a tough soil surface consisting mostly of iron and aluminum salts

In the West, the Rocky Mountain Forest exists on soils with relatively low fertility in a severe climate with low temperatures and frost-free growing seasons of generally 90 days or less. Annual precipitation is highly variable. Ponderosa pine is the most common species inhabiting the lower elevations along with lodgepole pine and quaking aspen. In the northern portion, at lower elevations, Douglas fir, western white pine and western hemlock are dominant, while at the higher elevations, spruce and true firs dominate.

The Pacific Coast Forest is the most productive forest region in the United States and probably in the world. This forest area is subdivided into two distinct contrasting forest types: (1) the wet west mountain slope, and (2) the dry east mountain slope.

The west mountain slope has a dry summer with very mild, wet winters during which 40 to 150 inches of precipitation fall. The soil is moderately fertile and the frost-free growing season varies between 100 and 200 days. These conditions promote rapid tree growth, frequently producing trees 200 feet tall and 6 to 10 feet in diameter. Douglas fir is the major dominant species associated with the redwoods in the south, while in the north, western hemlock and western red cedar are predominant.

The dry eastern mountain slope receives 15 to 30 inches precipitation annually on soils of moderate to low fertility. Ponderosa pine is the major dominant species associated with Douglas fir in the upper elevations.

Currently, more softwood timber is being cut than is being grown. Only in the forests of the East is 1/5 more softwood and 3/5 more hardwood sawtimber growing than is being cut. A major problem exists in the West where rather extensive old growth virgin forests are being heavily cut without matching timber growth. While the timber growth exceeds the timber cut in the East, it must be pointed out that a serious problem still exists. A reduced timber cut in the East has largely been responsible for this development, not a greatly increased growth. This means that the future will see more pressure put on the Western forests where the cut is now exceeding growth and where timber growth generally is not as rapid as it is in the East.

In most people's minds, the National Forests and the U. S. Forest Service include and administer the majority of forest land in the United States. Nothing could be further from the truth. Of 489 million acres of commercial forest land, Federal forest holdings amount to 21 percent while state and local forest holdings amount to 6 percent. The three largest agencies charged with primary administration of Federal forest lands are the U. S. Forest Service in the Department of Agriculture, the Bureau of Land Management in the Department of Interior (chief forests in Oregon and Alaska), and the Indian Service in the Department of Interior. Private commercial forest land holdings account for the remaining 73 percent. Of the private sector, forest industries own only 13 percent. This means that 60 percent or 296 million acres of our nation's commercial forest lands are privately owned. Also, 86 percent of these private ownerships are forest lands under 100 acres per owner with 13 percent of the private ownership holdings ranging between 100 and 500 acres. In reality, then, the most important forest land owner is the American family, since one out of every ten families owns a small tract of forest land.

The private small forest owner (less than 500 acres) constitutes one of the major forest problems. Timber productivity on these small tracts, which make up 60 percent of all commercial forest, is relatively low. By contrast, timber productivity on the forest industry and public forest lands is relatively high.

The contrast in ownership between commercial and non-commercial segments of forest lands is very sharp. Three-fourths of the commercial forests are privately owned. However, two-thirds of the non-commercial segment is publicly owned, largely by the Federal government. The non-commercial forests include forests reserved from timber use such as wild or wilderness areas of national forests, state or national parks, community watersheds, etc. Such areas in total do not account for more than 3 percent of the total commercial forest land in the United States.

Problems and Practices of Forest Management

About 10 percent (50 million acres) of the forest land in the United States needs to be planted for new timber production. Over 25 percent of the commercial forest lands have less than 40 percent of the trees which could be properly grown on those lands. Eighty-four percent of these poorly stocked forest lands are privately owned tracts mostly in the Great Lakes region and the Southeast. Successful planting has only been carried out on 10 percent of those forest lands capable of heavier timber stocking. Replanting these lands would provide one of the best means of increasing the future timber supply.

While logging is not able to completely eliminate wasting some part of the tree, the loss of one foot out of every four feet logged is a serious problem. This loss is not uniform for all types of logging, for 34 percent of the timber cut for lumber goes unused, while only 4 percent of that cut for pulpwood is lost. More efficient use of the tree tops and branches and plant residues such as sawdust, chips, and bark is possible. Sweden uses in excess of 95 percent of every tree harvested. Current products of these waste materials include fiber boards, pressed hard boards, pressed sawdust and chip fireplace logs, plastics, paper pulp, etc.

Certain forces may reduce or completely destroy timber productivity. Insects, disease, weather, fire, etc., may retard timber growth, stunt or deform trees, or eventually kill trees. Approximately 25 percent of the total sawtimber is lost to these combined destructive forces. About 10 percent of the standing timber consists of stunted, crooked or rotten trees. In general, timber quality nationwide is declining with defects that limit the utility of the logs. If we consider those factors directly causing tree mortality, we find insects (40%), weather (27%), disease (18%), and fire (6%) most important. However, in terms of their long-term effects on timber growth their degree of influence changes: disease (45%), insects (20%), fire (17%) and weather (9%). The most serious disease is heart rot, which attacks the stem of the tree, and is most serious in the Northern Forest and the West. The most extensive insect losses occur in the West with 60 percent of the damage being caused by bark beetles. Extensive fire prevention and suppression programs are responsible for keeping timber losses due to fire below those of disease and insects. Since most of the forest fires are man-caused, increased visits by recreationists can be expected to aggravate this problem. Despite this, since man causes the fire problem, it should be one of the more easily solved problems. Weather damage is variable both in frequency of occurrance and intensity of damage from ice, snow, wind, severe cold, and drought.

Sound management and logging practices can be initiated on nearly all forest lands to increase not only timber growth but timber quality. Generally, in selective cutting the older or more mature trees plus diseased, insect damaged and cull trees are logged during the first timber harvest. Logging operators must take all precautions to prevent damaging mixed age trees left untouched. This type of logging has probably the best influence to prevent the spread of insects and disease, while providing sufficient shade for the seedlings which are intolerant of bright sunlight. It also provides for a desirable mixed age stand permitting sustained timber production and some type of annual income. For some species, block or strip cutting in which the timber is entirely logged from the given area may be desirable. Some species, such as Douglas fir, require the bright sunlight and open ground of block or strip cutting for seedling establishment and rigorous growth. Under intensive management, single-species forests should be avoided. In Germany, where even-aged stands of conifers replaced mixed stands of softwoods and hardwoods, soils became severely podzolized. Mineral cycles in the soil failed to function, losses to insects, diseases, etc., increased and production of timber decreased.

cull: inferior or worthless

While wood products are very important, it must be pointed out that forest lands have a multiple use function, to serve a variety of purposes. Frequently, the value of these other uses exceed the value of commercial timber production. In the United States the actual income from commercial timber on national forests for one year is around $100 million. At the same time 200 million acre feet of water flowing from that forest land is estimated to be worth at least $600 million.

In the Rocky Mountain States, that area above 8,000 feet elevation represents only 20 percent of the land area, yet it produces 85 percent of the usable stream flow in those states.

The influence forest vegetation exerts in reducing surface water run-off, reducing soil erosion and improving storage of ground water is illustrated in Fig. 3. Reducing flood damage caused by loss of forest vegetation can only be achieved by revegetation of the land, not by building more flood control dams. Also, groundwater can only be replenished by water soaking into the soil and porous rocks, rather than running off to the oceans over the land surface via streams and rivers.

In those forests having only light to moderate densities of trees, the growth of shrubs, forbs and grasses as understory vegetation provides a valuable source of habitat for livestock and game animals. About 20 percent of the nation's

understory vegetation: that plant life growing on the forest floor beneath the crown of the forest trees

EFFECT OF SUMMER STORMS

Ephraim Watershed, Utah

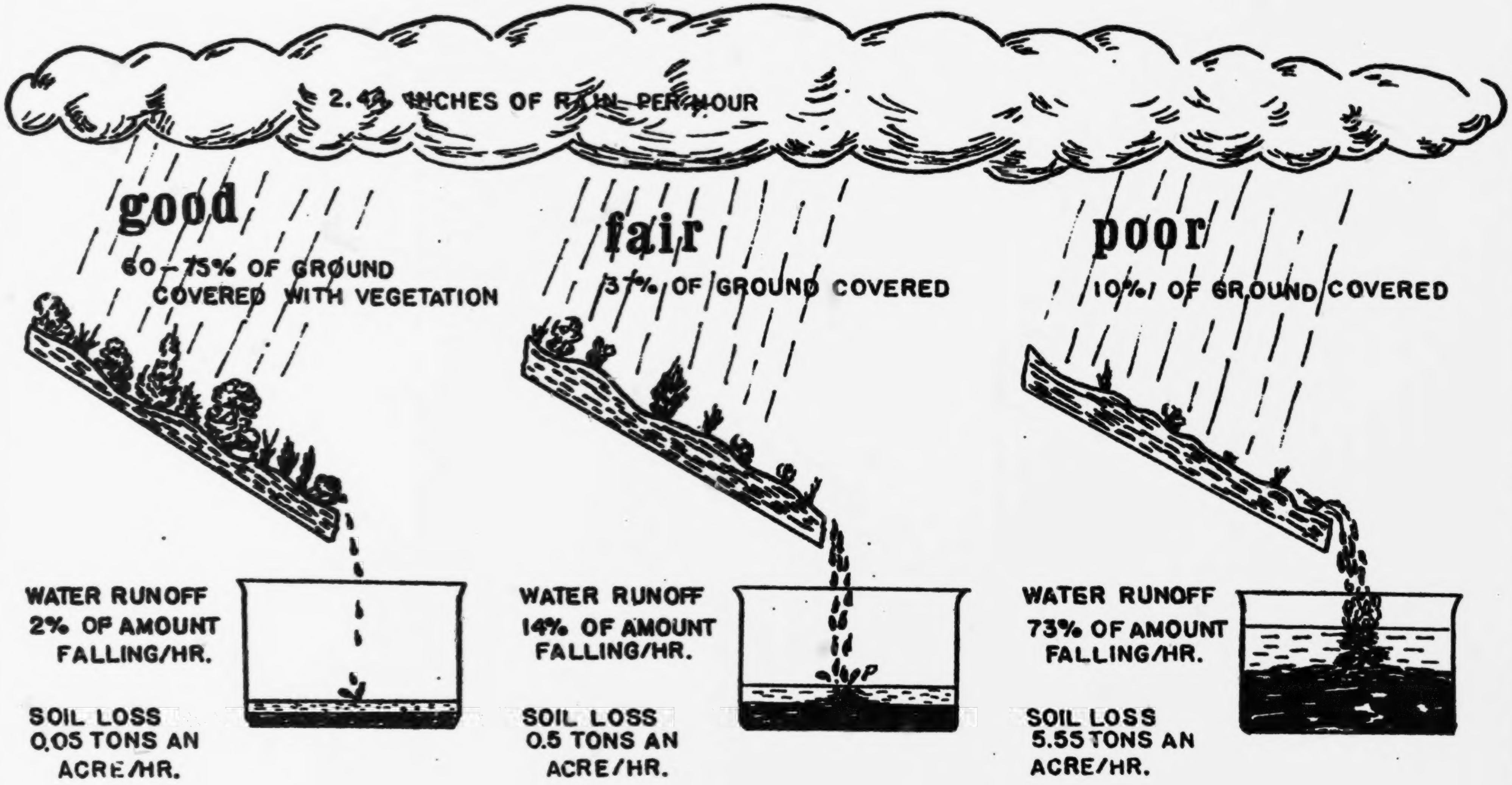

2.43 INCHES OF RAIN PER HOUR
good
60–75% OF GROUND COVERED WITH VEGETATION
fair
37% OF GROUND COVERED
poor
10% OF GROUND COVERED
WATER RUNOFF 2% OF AMOUNT FALLING/HR.
SOIL LOSS 0.05 TONS AN ACRE/HR.
WATER RUNOFF 14% OF AMOUNT FALLING/HR.
SOIL LOSS 0.5 TONS AN ACRE/HR.
WATER RUNOFF 73% OF AMOUNT FALLING/HR.
SOIL LOSS 5.55 TONS AN ACRE/HR.

FIG. 3

sheep and 13 percent of its cattle graze on national forest lands. Many cattle and sheep are also grazed on privately owned forest lands of the eastern and southeastern portions of the United States. Also, 33 percent of the nation's big game, such as deer, elk and moose, find food, shelter, and breeding areas on these same national forest lands. Additional game species found there include wild turkeys, grouse, snowshoe rabbits and black bear.

Outdoor recreation has increased so rapidly that by the early 1960's over 15 million acres of national forest lands were primarily devoted to that use. In 1960, privately owned forest industry lands accommodated 6 million visits from outdoor recreationists. In 1963, the national forest lands served 123 million outdoor recreation visits. Typical of these were camping, hunting or fishing, skiing, touring with oversnow vehicles, picnicking, and boating. Hiking, horseback riding and canoe trips into wilderness areas provide the visitor with the increasingly rare opportunity to enjoy the beauty and solitude of the landscape, native plants and wild animals without the sights, sounds and smells of an industralized and mechanized society.

Forestry management of the future will certainly be directed toward those forestry practices which not only promote timber production but also promote sound watershed management, range management, wildlife management, outdoor recreation management, wildlife management, and compatability with preservation of esthetic values of historical features, scenery, wilderness areas and other features providing irreplaceable enjoyment and inspiration.

SUGGESTED REFERENCES

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Carhart, A. H. 1954. Timber in Your Life. J. B. Lippincott Co., Phil.

Clawson, Marion. 1963. Land for Americans. Rand McNally & Co., Chicago.

Dasmann, R. F. 1959. Environmental Conservation. John Wiley & Sons, Inc., N. Y.

Highsmith, R. M., J. F. Jensen and R. D. Rudd. 1962. Conservation in the United States. Rand McNally & Co., Chicago.

Smith, Guy-Harold, ed. 1965. Conservation of Natural Resources. John Wiley & Sons, Inc., N. Y.

United States Department of Agriculture. 1958. Timber Resources for America's Future. Superintendent of Documents, U. S. Printing Office, Wash., D. C.

United States Department of Agriculture. 1962. Forest Conservation Teaching Kit. Forest Service, Wash., D. C.

United States Department of Agriculture. 1963. Materials to Help Teach Forest Conservation. Forest Service. Wash., D. C.

United States Department of Agriculture. 1964. Highlights of the History of Forest Conservation. Forest Service, Wash., D. C. Agriculture Information Bulletin No. 83.

RESOURCE UNIT

Time Allotted ______

Unit Objectives

1. To convey an awareness of man's use, management, and control of forest resources.
2. To develop an understanding of the relationship of forests to the total ecosystem.
3. To develop an awareness of individual responsibility in protecting forest lands.

Concepts

1. To understand the interrelationship between forest, water, soil and wildlife.
2. To understand methods of management, control, conservation and protection of forests.
3. To appreciate his own individual responsibility in maintaining and protecting forests.

Activities

Demonstrations and Investigations

a. Fire lanes
b. Habits of insects injurious to trees
c. Cords
d. Measure board feet
e. Cost of reforestation
f. Cost of lumber
g. Climate and forest
h. What is a watershed?
i. Forest location
j. Tree products
k. Planting new trees

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. Wood Products Used by Man	
A. Fuel	Film: Forest produces
B. Lumber	
1. Construction	
2. Furniture	
3. Miscellaneous	
C. Pulpwood	
1. Paper	
2. Platics, rayon, cellophane, etc.	
3. Chemicals	Activity: Destructive distillation of wood
D. Plywood and veneer	
1. Construction	
2. Furniture	
E. Miscellaneous	
1. Poles and pilings	
2. Ties and mine timbers	
3. Cooperate and turned products	
4. Distillation products	
5. Charcoal and shingles	
II. Forest Lands of the United States	Film: Voice of the Forest
A. Six forest areas, characteristic tree species and environment	Activity: Climate and watershed
1. Northern Forest	
2. Central Hardwoods Forest	
3. Southern Forest	
4. Tropical Forest	
5. Rocky Mountain Forest	
6. Pacific Coast Forest	
B. Timber growth and harvest states	
1. East	
2. West	
C. Ownership of forest lands	
1. Public	
2. Private	

III. Problems and practices of sound forest management

A. Rehabilitation of decadent forest lands

B. Destructive forces

Activity: Fire lane

1. Disease
2. Insects
3. Weather
4. Fire

C. Logging practices
1. Selective cutting
2. Block cutting
3. Mixed species forests

D. Multiple Use Concept
1. Watersheds
2. Rangelands
3. Wildlife
4. Outdoor recreation
5. Esthetic values

EQUIPMENT LIST

Large pan or cookie sheet

Flask

Thermometer

Condenser

One-hole rubber stopper

Box 1' x 1' x 1'

Electric hot plate or Bunsen burner

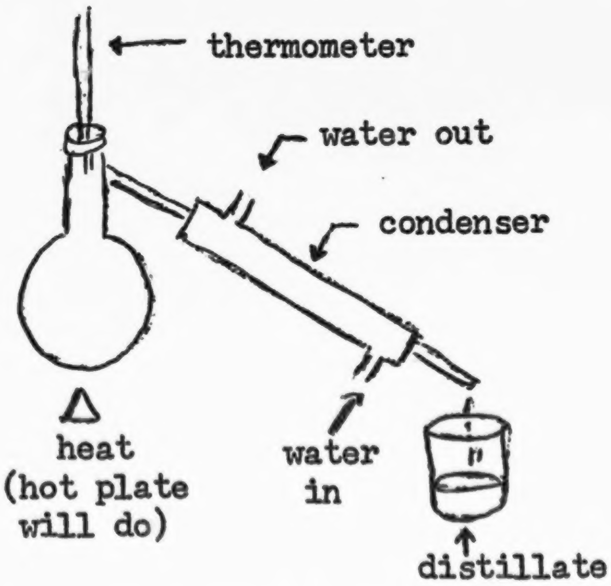
SUGGESTED ACTIVITIES

Demonstrations and Investigations

Fire Lanes

1. Place a large cake pan or cookie sheet (12" x 14") with ½" of sand. Cut filter paper or circles of paper into fourths. Glue onto a match (trees) head end up. Place into sand. Prepare one pan with strips (fire lanes) between the "trees". In the other pan arrange the "trees" without fire lanes. Light both and observe.

2. Prepare a distillate from wood to illustrate the method of obtaining fluids useful to man from wood products. (Tar, pitch turpentine from pines; tannin from chestnuts, oaks, hemlock.)



Helpful hints: The main products from the destructive distillation process are acetic acid, methyl alcohol, and tar. Destructive distillation begins about 250°C and is finished about 300°C. Practically all the water, acetic acid, wood alcohol and wood tar will have been evolved. About 60% of the green wood will be water. Use a closed retort, as illustrated, and green wood. The liquid can be further distilled to separate the components.

Cords

3. Measure the volume of a cord of wood. Measure the room. Determine how many cords of wood could be stocked in the room. A cord of wood is 4' x 4' x 8'.

$$4 \times 4 \times 8 = 128 \text{ cubic feet}$$

Measure Board Feet

4. Obtain a concept of board feet by bringing in a box built just the size of 1 cubic foot. Then bring a board and measure the volume and see that it too has one board foot of lumber in it.

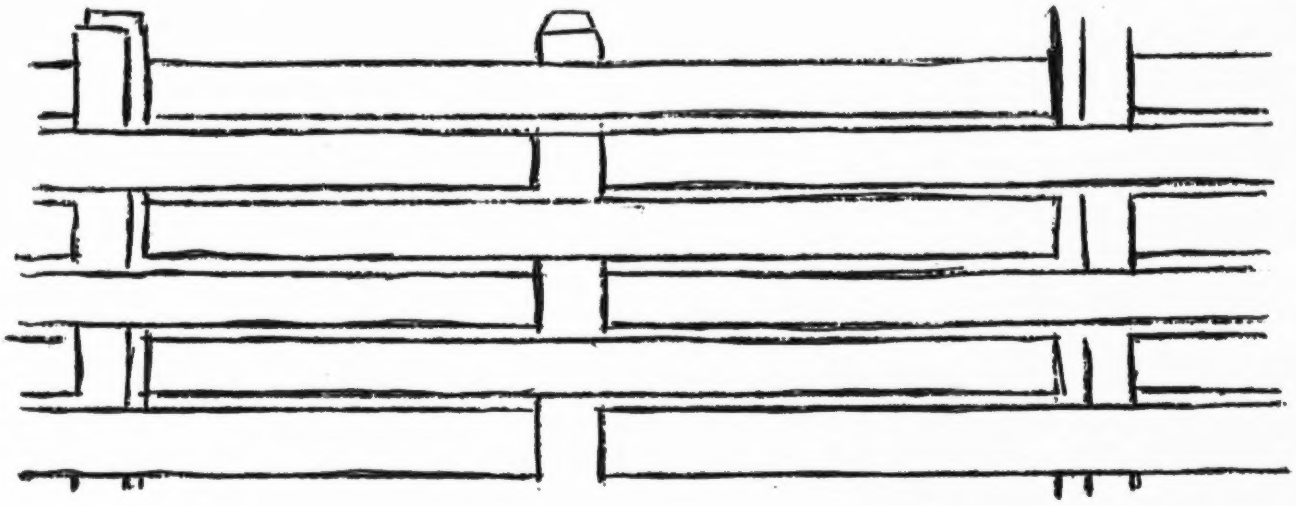
width x length x depth = board feet
board feet = cubic feet

Cost of Reforestation

5. Plan the cost of reforesting a hillside near your school. Work out the possibilities of success of the forest growth.

Cost of Lumber

6. Measure a back yard and determine how much it would cost to fence it with the "woven lumber technique.



Ring Counting

7. Bring in a cross-section of a tree. Date the beginning of the tree. What event in history took place then? Continue to count the rings. Correlate history with the growth of a tree for a display.

Climate and Forest

8. Study the types of soil, the amount of rainfall, the length of the growing season, and the temperature required for the best growth of forests in various forested areas. Stress finished products and quantity of wood needed to produce those products.

What Is a Watershed

9. Examine the meaning of watershed. Illustrate with models. Discuss the watershed for your community.

Tree Products

10. List things at home and school that come from trees. What about new products?

Suggestions:

- pulpwood
- plywood
- plastics
- textiles
- paper
- explosives
- turpentine
- veneer
- lumber
- hardboard
- wallboard
- tars

Forest Location

11. On a map of the United States, chart the location of the forests. Name principal trees in each area.

12. Grass does not grow under cedar trees. Ranchers in Texas decided to remove the cedar trees from the hillsides to allow more grass to grow. After the cedar trees were removed, the ranchers found that they had less grass for their cattle instead of more. Can you explain this?

Field Trips

Study Habits of Insects Injurious to Trees

1. Try to find some trees damaged by insects. Consult the county extension agent for information of harmful insects.

Planting New Trees

2. Plant seedling on school property with the cooperation of the principal or superintendent.

3. Visit a hillside with trees growing on it. Notice the difference in the soil where trees cover the slope and where the slope is bare. Collect samples of soil from both areas. Plant grass seeds in the two types of soil. Explain the results.

SUGGESTED VISUAL AIDS

Films

Days of a Tree, 28 min., color, AFPI.

Forest Conservation, 11 min., color, EBF.

Forest in a Museum, 10 min. 45 sec., color, USDA.

Forest Patterns - Beauty and Use, 19 min., color, USDA.

The Forest Produces, 11 min., color, EBF.

Forest Ranger, 13 min., color, EBF.

From Trees to Lumber, 14 min., color, AFPI.

From Trees to Paper, 13 min., color, AFPI.

Heritage Restored, 14 min., color, USDA.

Introduction to Forest Adventuring, 27 min., color, IFB.

Islands of Green, 24 min., color, USDA.

The Land Changes, 13 min. 30 sec., color, USDA.

Life in the Woodlot, 17 min., color, MHB.

Let's Visit a Tree Farm, 11 min., color, COR.

Patterns of the Wild, 27 min. 30 sec., color, USDA.

Realm of the Wild, 25 min., color, USDA.

Tent Flaps and Flapjacks, 25 min. 30 sec., color, USDA.

Treasures of the Forest, 13 min., color, COR.

The Tree, 10 min., color, CF.

Tree Bank, 13 min., color, USDA.

Trees to Tame the Wind, 10 min., USDA.

Voice of the Forest, 26 min. 45 sec., color, USDA.

Water for the West, 24 min. 30 sec., color, USDA.

Watershed Wildfire, 21 min., color, USDA.

Film Loop

Olympic Elk, 4 min., color, Ealing.

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

FORESTS

SOURCES OF FREE TEACHING MATERIAL

Director, Division of Information
and Education
U. S. Forest Service
U. S. Department of Agriculture
Washington, D. C. 20250

Chief, Division of Information
and Education
U.S. Forest Service, Region 2
Federal Center, Building No. 85
Denver, Colorado 80225

Chief, Division of Information
and Education
U. S. Forest Service, Region 4
Forest Service Building
Ogden, Utah 84403

Public Information Officer
Bureau of Indian Affairs
U. S. Department of Interior
Washington, D. C. 20240

Information Officer
Bureau of Land Management
U. S. Department of Interior
Washington, D. C. 20240

American Forest Products
Industries, Inc.
1835 K Street, N. W.
Washington, D. C. 20006
or
260 Denver Club Building
Denver, Colorado 80202

Director of Education
The Conservation Foundation
1250 Connecticut Avenue
Washington, D. C. 20036

Conservation Chairman
The Garden Club of America
598 Madison Avenue
New York, N. Y. 10022

Supervisor, Medicine Bow
National Forest
U. S. Forest Service
Laramie, Wyoming 82070

Supervisor, Big Horn National
Forest
U. S. Forest Service
Sheridan, Wyoming 82801

Supervisor, Bridger National
Forest
U. S. Forest Service
Kemmerer, Wyoming 83101

Supervisor, Shoshone National
Forest
U. S. Forest Service
Cody, Wyoming 82414

Supervisor, Black Hills
National Forest
U. S. Forest Service
Custer, South Dakota 57730

State Forester
Wyoming State Forestry
Division
Capitol Building
Cheyenne, Wyoming 82001

CONSERVATION EDUCATION IMPROVEMENT PROJECT

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UNIVERSITY OF WYOMING

College of Education

MINERALS AND OIL

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MINERALS AND OIL

TEACHER'S DISCUSSION

This unit can become quite involved and lengthy unless the major unit goal is kept in mind, that of emphasizing the conservation of minerals and oil rather than their science. Therefore, much time and energy may be saved by examining some of the most commonly used minerals, their properties and occurrence. The most commonly used materials are not always the most abundant, however. Those minerals which this unit will treat are aluminum, asbestos, copper, graphite, gypsum, iron, lead and antimony, limestone, magnesium, mercury, mica, nickel, salt, sulfur, tin, tungsten and zinc. Samples of at least some of the refined minerals listed above are generally available. The ores from which they are extracted may be difficult to obtain unless specifically ordered from a general scientific supply house which carries geological samples. A "rockhound" in the community might have some or all ore samples needed.

Metallic Minerals

Aluminum

Aluminum is a silver colored metal weighing about three times less than iron. It is hard enough for many useful purposes, however, and is the most common metallic element found on the earth's surface. Although commonly found as a component in many surface rocks, its ore bauxite is not common. Bauxite is a clay-like material found principally in the southern United States. In its pure form it is an off-white color; however, iron compounds and other impurities cause it to be mottled gray to brown. The metal is extracted by heating the ore to remove the water, forming a substance called alumina. The alumina is the material from which the metal is ultimately extracted. Pure aluminum is quite soft, bending and scratching easily. However, by mixing the aluminum with other metals, alloys are formed which can be very hard and strong. For example, a common substance on the market is duralumin and is formed from the addition of copper and magnesium to aluminium. This material may be made as hard as steel but will weigh only one-third as much. Another alloy of alluminum contains such metals as iron, zinc, copper, and assorted other metals which when combined are stronger than steel with about the same weight as duralumin. Other alloys of aluminum are resistant to corrosion and are used in place of tin to coat the insides of cans.

(box' ite)

alloys: any substance composed of two or more metals or metal and non-metal

Aluminum alloys are used in the manufacture of such items as airplanes, automobile engines, outboard motors, motor cycle motors, railroad cars, truck bodies and power shovels. The ore, bauxite, has other uses such as in the preparation of abrasives or grinding powders, grinding stones, furnace bricks, and chemicals such as alum. The chemicals manufactured from aluminum ores are used in dying cloth, making paper, tanning leather, and as flocculating agents in city water supplies.

Bauxite is formed at the surface in hot moist climates from certain types of clays. The ore is mined principally in the southern parts of the United States in Arkansas and Georgia in open pits; most deposits are small. Our total production of aluminum ore is 1.4 million tons annually. There are larger deposits in South America, Asia and Africa. The production of ore in the northern parts of South America is 3.5 million tons annually. Most of that ore is washed and heated at the site of extraction and then sent on to the United States and Canada for processing into aluminum.

The known aluminum reserves are expected to last between two or three centuries at the present rate of use.

Copper

Copper is a dark red metal in its native state. It is rather soft but heavier than iron. Although raw copper nuggets are scarce, the largest found weighed 420 tons. Several types of ores yield copper in commercial quantity; bornite, azurite, cuprite, and enargite. The most widely occurring copper mineral is chalcopyrite.

Copper ranks seventh in value of domestic minerals produced. Many accessory metals are associated with the copper ores. They are recovered during the processing of the copper from the ore by electrolytic refining. Some of the accessory metals are zinc, arsenic, antimony, bismuth, and platinum.

domestic minerals: minerals found in the United States

electrolytic refining: substances being refined conduct electricity while in a molten state, thus permitting recombination of ions and recovery of specific elements

There are four major copper producing areas in the world. Two of the four major areas are in the United States: the Rocky Mountain region and the Great Lakes Basin -- Shield area found in Michigan and spreading into Monitoba, Ontario and Quebec, Canada. The two remaining regions are located in Peru and Chile and Northern Rhodesia and the Belgian Congo on the Central African Plateau.

Shield area: (see page 3)

The metal has wide use but is of major importance in the electrical industry. Properties of copper and its alloys make it superior as a conducting medium for electrical current. Other properties include the ability to transfer heat, rust and corrosion resistant, durability and strength. The metal is easily worked. Some common recognizable alloys are brass, a copper-zinc mixture, and bronze, a copper-tin mixture. One-third of all domestic uses of copper are for electrical use: generators, motors, electrical locomotives, switchboards, automobiles, rods and wire. Other uses of copper include bronze welding rod, bronze wire, copper tubes and a variety of plumbing supplies, gear parts, and chemicals. Copper chemicals are useful for antifouling paints for ship bottoms, chemical analysis and reagents. Copper is a highly reuseable metal. For each new ton of copper produced, three-fourths of a ton of copper can be salvaged from scrap.

Raw copper deposits are thought to have formed from the deposits left in pore spaces, cracks and holes in lava, and conglomerates when the copper ladened steam escaped from magma deposits and migrated into those areas to plate out leaving behind raw copper crystals, sheets and nuggets.

Nearly 2 million tons of copper are used in the United States annually. Chile is second in copper production only to the United States. However, 95 percent of the industry there is American-owned.

Iron

Iron is one of the eight most abundant elements composing the earth's crust. Pure iron is a malleable, gray metal, somewhat soft. It does not have the electrical conductivity of copper. It is reasonably safe to say that iron is the most useful and important metal to man. Some 200 million tons of metal are used annually in world production. Several iron ores are important: pyrite, siderite, hematite, limonite, and magnitite. The occurrence of these ores may be segregation deposits crystallized from once mother rock, contact metamorphic deposits, sedimentary ores, replacement deposits formed by water, residual deposits of limonite as found in Virginia, and placer deposits of magnetite sands.

Iron oxides are used as pigments in paints and oils and are responsible for the color pigments ocher, umber, and sienna.

Shield area: stable area of a continent since Pre-Cambrian time (over 600 million years ago) that has never been covered; the stable area in North America is called the Canadian shield; the term shield was suggested because the surface of the shield area is gently arched like the shield of battle in medieval times

conglomerates: water-rounded rock or pebbles cemented together by another substance

magma: molten lava that remains below the earth's surface

plate out: to be deposited upon a surface in relatively pure form

malleable: capable of being shaped by hammers or rollers

(pie' rite)

segregation deposits: sorted or stratified

contact metamorphism: (see page 4)

placer deposits: (see page 4)

The most important iron ore is hematite. Several types of hematite are known. All produce a dark rusty-red streak on a porcelain streak plate which distinguishes this ore in its massive form from other iron ores such as magnitite. Red hematite forms in the soil as a result of the weathering other iron-bearing minerals endure.

Iron ore is smelted in tall round steel shells lined with fire brick called blast furnaces. Near the bottom of the furnaces are pipes that bring in "blasts" of air. Coke is used for heating the ore and limestone is used as a flux. Hot air forces the fire upward melting the iron from its ore. The liquid metal flows to the bottom, the stone left behind becomes slag and waste gases are released through pipes. The molten metal is called pig iron, an impure iron that must be treated in various ways before it is used. Cast iron is pig iron that has been placed in molds. Cast iron is brittle and not very strong. Some common uses for cast iron are sewer pipe, radiators, and machine parts which do not have to undergo excessive strains.

Wrought iron has had most of the carbon impurity removed from it and has been cleaned of most of its slag. This is a tough, strong and malleable metal. It is used in rivets, chains and porch decorations.

Steel is made by mixing pig iron with scrap metal. Carbon is burned out of the pig iron; a fluorite flux is added along with nickel, borax and other material to make the steel strong and hard.

Iron and steel, like copper, is highly reuseable and large quantities can be used over again and again by mixing them with pig iron. Nearly 50 million tons of scrap ore are used each year which is equal to over 90 tons of high-grade iron ore. Steel is used for ship plate, armor of various types, weapons, wire, springs, automobile engines, cable cars, ball bearings, elevators, and structural steel.

Lead and Antimony

Lead was used in the days of Rome in the manufacture of dishes, cookware, water pipes and lead-lined vessels. Since a human intake greater than 1 mg is toxic, the decline of Rome may have been caused, in part, by a slow poisoning of the Roman social leaders, wealthy enough to use lead in their everyday living activities. The poorer classes of Roman citizens were not as extensively affected by lead

contact metamorphism: pressure accompanied by heat and chemical activities that occur near or at the contact zone between the intruding magna and the rock

placer deposits: water deposited gravels and sand containing raw native minerals such as gold, copper, tin, etc., in sufficient quantity for commercial production

smelted: the fusion or melting of an ore to separate out the desired metal

flux: a substance which can be added to aid the fusion of several metals or minerals; in the case of the refining of scrap or other metal, certain salts may be used to combine with the impurities causing them to float or coagulate for easy removal poisoning. Thus a deterioration of the Roman leaders and the progressive social class may have contributed to the decline of Roman power.

Lead has a deleterious effect on man. The result is a shorter life span and poor reproductive capacities. Lead poisoning is manifested by miscellaneous diseases such as paralysis of the extremities, insomnia, blindness, and mental disturbances.

deleterious: harmful

Lead is a heavy, soft metal and does not rust. The same lead pipes of the Romans that carried water to their homes and baths are still in use today after nearly 2000 years. The most important ore of this metal is galena, a sulfide of lead that forms shiny blocks of metallic gray crystals. Lead is found from the Appalachian Mountains to the Rockies. The largest mines, however, are in Missouri and Idaho.

More than half the lead used each year is from scrap lead sources. Lead and its compounds are used in paints, solders, bearing metals, foils, plumbing supplies and the like. Pewter is an alloy of lead and tin. When blended with antimony, the lead alloy is much harder than the pure metal. Printers type metal contains as much as 20 percent antimony. Bullets and shot are also hardened with antimony and so are machine bearings and telephone cable coverings. Mexico and Peru have been the principal sources of foreign export.

The ore of antimony is stibnite, a sulfide of antimony. Stibnite is a metallic, gray material often associated with arsenic minerals, lead ores, and cinnabar (ore of mercury). Stibnite is often found in crystal forms, the finest known are over a foot long from Japan. The antimony metal, refined from stibnite, is bluish-white and very brittle and can be powdered easily. Its primary use is for alloying purposes, with 75 percent of the production used to alloy lead. Other uses include pigmentation in paints. Large amounts of antimony once came from China, but since 1940 most of the metal that is imported has come from Mexico and Boliva. This metal, like lead, can be reused after salvage.

(stĭb' nite)

Magnesium

Magnesium is a silvery metal that burns brilliantly. It is only two-thirds the weight of aluminum. The mineral brucite, mined in Nevada and Canada, and the mineral magnesite, mined principally in Europe and in some places in North America, are the important sources of magnesium. Magnesium may also be obtained from dolomite and sea water.

It is reported from various sources that the supply of raw materials seems inexhaustible; Canada has the largest known deposits.

Its high strength and low weight have made it important in the construction of structural metal for aircraft. It resists alkalies, but is highly corrosive and is attacked by most acids. Its surface is readily oxidized.

alkalies: hydroxides of the metals in the first group or family of the periodic chart of the elements, plus ammonia

The metal is used in fireworks and in flares. When mixed with other metals such as aluminum, copper and zinc, it forms strong alloys. Alloys of magnesium which do not burn are used in the automotive industry, in tooling industries, and textile and foundry equipment.

The ore, magnesite, is often made into fire bricks, fertilizer, face powder and some types of paper. "Burned" magnesite is mixed into cement where concrete floors are required as it causes those floors to be warmer and softer than the usual portland cement.

Mercury

Most mercury comes from the ore, cinnabar. It is a liquid at room temperature, silvery bright, and 13½ times heavier than water. Cinnabar, a sulfide of mercury, is most widely found in Yugoslavia, Spain and Italy. American deposits are not plentiful, but the best are in California, although Nevada, New Mexico, and Texas have small deposits. The mines of Spain were worked prior to Roman days and are now over 1,000 feet deep. The ore may be colored various shades of red. It is dull, soft and clay-like. The mineral is thought to have been dissolved by steam from hot magna or lava and redeposited into holes and fissures of lava rock far from its original source.

Mercury is most often directly used in thermometers, automatic switches, liquid barometers, and other electrical devices. However, 67 percent of the mercury produced is made into chemical compounds which may be used in medicines, antiseptics, and in explosive devices. Mercury paint is used on ship bottoms to kill barnacles which might attach themselves to the hull.

Nickel

Nickel is a silvery gray substance used in the five-cent piece. Iron meteorites contain up to 15 percent nickel. The metal occurs principally as hugh masses of nickeliferous pyrrhotite in Canada. Other ores are niccolite and chloanthite. Niccolite is an ore composed of nickel arsenide, is copper-colored and associated with Canadian deposits.

(pir' ah tite)

Stainless steel is a commonly known alloy of steel and nickel. Just enough nickel is used to keep the steel from rusting. Nickel is also used in pipes, cooking vessels, and trim on office buildings and the like. Other uses are found in airplanes, automobiles, armor plate for war purposes, and machinery. Measuring instruments and watch springs are also made of nickel alloys. Steel-nickel alloys are used in electric stoves, toasters and heaters. Money metal is copper and nickel alloys. The United States has almost no known nickel reserves. Since we are dependent upon foreign supplies, nickel has been purchased for stock piling.

Tin

Tin has been used for more than 3000 years. Tin at that time was melted with copper to form bronze which was nearly 90 percent copper to make axes, swords, statues and furniture. The Phoenicians obtained ore in England and sold it in Egypt and other countries. England still produces large quantities of tin, but the ore is becoming poor and is being worked out. Cassiterite is the most important ore of tin. It is generally associated with tungsten ores and pegmatites. The most important sources of tin ore are alluvial deposits in China, the Malay Peninsula and the Dutch East Indies. In the United States, some small veins of cassiterites have been unsuccessfully worked in Virginia and California.

alluvial: water-deposited sediments which originate from erosion of soil and rocks

Although bronze is still used today, other extensive uses have been found for tin. Tin is used to coat sheet iron to prevent rust. Terne (turn) is a tin-lead alloy plating used inside gasoline tanks. Tin is also used for coatings on pans, food grinders and other kitchen utensils. Solder is also a tin-lead alloy. Other tin alloys are made with antimony.

There seems to be no new discoveries of large ore bodies or rich placer areas. The prospect of tin supplies running out in due time is a serious possibility.

Tungsten

Tungsten is hard, heavy, gray-white metal. Its melting point has the second highest melting point of all the elements, and it is the strongest of all metals, yet is highly elastic. Tungsten's greatest value is in the use as a filament in converting electric energy into light energy.

Wolframite and scheelite are the two most common (she' lite) ores of tungsten. Wolframite is principally found associated with quartz veins and granitic rocks enriched with pegmatite solutions. The largest occurrences are in Portugal, Asia, and Bolivia. Scheelite is associated with contact metamorphic rocks where granite has intruded. It is generally associated with garnet and epidote. It has also been found with cassiterite, topaz, fluorite. It (kă set' ah rite) fluoresces blue to yellow, and it is mostly found in Nevada and California.

Tungsten is mixed with steel to produce alloys that withstand high temperatures and wear well. An alloy made of carbon and tungsten produces tungsten carbide, the hardest substance made by man. It is nearly as hard as diamond. Tungsten carbide bits last from 50 to 100 times longer than steel.

Zinc

The principal ore of zinc is sphalerite, a sulfide (sfall ah rite') of zinc. Impurities in the ore mottle it yellow, red, orange and black. By placing dilute hydrochloric acid on the ore rock a noticable odor of hydrogen sulfide can be detected. The ore is closely associated with galena (lead sulfide ore). Other minerals present in sphalerite are gallium, indium, and cadmium. Other zinc minerals occur (gal' ē um) but are not found commonly. The largest zinc mine in the United States is located at Franklin, New Jersey. One hundred forty-seven zinc minerals have been found in the Franklin mine. However, willemite, zincite and franklinite (will ah mite) are the most important minerals found in the Franklin mine. The purity of this zinc deposit is unsurpassed anywhere in the world. Sphalerite is mined in the United States and Canada with a large group of mines located in the tri-state district at the junction of Missouri, Kansas and Oklahoma.

The United States leads the world smelter output of zinc. Zinc imports into the United States come principally from Canada, Newfoundland, and Mexico.

Zinc has a great number of uses and is called upon heavily by domestic consumers. Coatings for steel, for galvanizing sheets and wire, manufacturing of brass for hinges and door knobs, dye castings and the production of zinc oxide for use in dry cell batteries are among the principal uses. Rolled zinc is used in lithography and photoengraving, in roofing material, and articles for wearing apparel.

Zinc oxide is also used in the rubber industry, and in the making of glass, as a paint pigment, and a pharmaceutical compound.

Non-metallic Minerals

Asbestos

Until 1865, asbestos was only a curiosity, but it had been previously used to make cloth by the Romans. The mineral is a crystalline fibrous material principally derived from deposits of serpentine (a hydrous-magnesium silicate). Asbestos may be spun, has a good resistance to high temperatures, and a low water absorption characteristic. It is usually found in veins or irregular masses with the fibers running crosswise in the vein. If the vein is four inches wide, the fibers will be four inches long.

Asbestos is used on aircraft and other military equipment, brake bands, clutch facings, and as insulation covering for electric wires. Roofing, tile, wall board, siding and shingles, gaskets, packing, and chemical fibers are other products using asbestos. Glass wool has been developed as a substitute for some grades of asbestos. A glass-asbestos textile has also been developed. At times asbestos has been our third largest non-metallic import. Vermont, however, has good deposits of asbestos. It was estimated from known reserves in 1945 that only 20 to 30 years of production were known. Canada produces nearly 50 percent of the world's supply of long-fiber asbestos with Russia ranking second. Africa, too, has been exporting more asbestos recently.

Graphite

A form of carbon, graphite has properties which differ extensively from either coal or diamond. It is soft enough for a fingernail to scratch it, opaque, resistant to heat and acid, and is a good conductor of electricity. Graphite is principally found in Ceylon, Madagascar, the U.S.S.R., Germany, Canada, Korea, and Mexico. There are other countries not mentioned which also have good graphite deposits.

Its principal use is in lubricants, pencils, dry cell batteries, and paints. The electric industry makes extensive use of graphite. Graphite has in recent years taken on new uses, such as acting as a control or moderator for the the slowing of activity of neutrons in atomic "piles" or neutron reactors to control the atomic reactors for experimental and domestic purposes.

The modern pencil is a mixture of graphite and clay. The more clay present the "harder" the pencil. Graphite may be manufactured from coal waste, coke, or petroleum coke mixed with quartz, sand and sawdust. However, manufactured graphite does not make good pencils.

Gypsum

Gypsum has been used almost since civilized man has been on earth. Plaster was made from gypsum by ancient Egyptians, Romans and Greeks. Pure gypsum is white, but impurities may color it gray, buff to brown and even red. There is a commonly found crystal form of gypsum known as selenite, loose, free-growing crystals found in clay beds. Crystal forms and the more massive forms are soft, easily scratching under pressure of the thumb nail.

Most rock gypsum was formed near the shores of ancient seas. As the lagoons or inlets dried up salt and gypsum settled or precipitated out into layers. The beds that formed built up over the years of deposition to as much as 1,400 feet thick.

Gypsum is ground up and made into plaster of Paris. The gypsum is heated, driving out the water from its molecular structure. The dried powder thus formed upon mixing with water, hardens again into gypsum.

This reconstituted gypsum can be squeezed between layers of heavy paper to form "plaster" wall board or rock lath. Certain types of acoustic tile and ceiling tiles may also contain quantities of gypsum. Plaster of Paris may also be used as a filler in paint and blackboard "chalk". Gypsum is being used at the rate of over 10 million tons a year, but known world supplies will be assured for many centuries to come.

Limestone

This rock is composed of calcium carbonate (lime) of very fine texture. The mineral is deposited as a chemical precipate or in the form of shells of aquatic organisms.

The shell deposits may be from sea or freshwater organisms. Many limestone deposits are fossil-bearing and often provide an excellent opportunity to the amateur collector to discover interesting creatures which once lived in the ancient seas.

Limestone is used as a building material; when ground and heated, it can be used to produce plaster and cement. Limestone is added as a flux when lead and iron are smelted. Still other uses for limestone include purification of drinking water, and also aiding in the refining of sugar, salt, gas, and some oils. It is used in making glues, gelatin and soap, glass, varnishes and paints, toothpaste, putty and linoleum. Chemicals from lime are used as bleaches and disinfectants. Its other uses include use as a soil additive to neutralize acid soils. Over 20 million tons of limestone are used each year.

Calcite is the principal constituent of limestone and may on occasion form crystals useful for optical purposes called Iceland Spar. Many different types of limestone are known, such as chalk, remains of tiny sea creatures, and travertine, hot springs mineral deposits, ancient coral reefs built up of ancient corals, and coquina, a conglomerate of the remains of small shelled animals such as clams and snails cemented together with silica or lime. (cal' site)

Mica

Mica comes in several types or varieties, muscovite and phlogopite, biotite which grades into phlogopite, vermiculite and several other miscellaneous forms, each having some special use. This mineral is extremely common, but is rarely found in large enough quantity to have commercial value. The micas are essentially silicates of aluminum; some potassium and iron may be present which provides for the wide variety of characteristics of mica. (flŏg ah pite)

Mica has transparency, perfect cleavage and may be colorless to black. It is tough, elastic, flexible, and highly nonconductive with regard to heat and electricity. Muscovite is the most valuable of the different varieties. The best grades are clear or stained a light red. This type is usually found associated with pegmatite dikes. Mica can easily be observed in common granite as small shiny flakes, or in sand and mud. Black-colored, iron-rich micas have little commercial value. Vermiculate is marketed as "zonolite" and is used as an insulation. Other uses include electrical insulators, resistors, marine compass dials, boiler gauges, and bridges in radio tubes, furnace peepholes and stove fronts. It is used in corrosion-resistant paints, resin varnishes and plastics.

Shortages of clear mica during World War II led to the replacement of mica in some uses by substitutes. A material made from bentonite clay can be made into high tension condensers, also specially treated paper can replace mica as an electrical insulator. A type of plastic with the characteristics of mica is being sought after as a substitute.

The United States produces more mica and uses more than any other country in the world. Seventy-five percent of the sheet mica has come from North Carolina and New Hampshire. It is stated by several sources that Colorado has extensive reserves of quality mica. The United States imports certain types of mica in great quantities; most of the highest grade muscovite comes from India.

Sulfur

Native sulfur has been known and used since ancient times, the primary source coming from the island of Sicily. There it is found between beds of gypsum, sandstone, and limestone. Sulfur is yellow, brittle and crystalline. Under the sedimentary deposits of Louisiana and Texas large beds of native sulfur are present. Pyrite and marcasite, iron sulfides, and pyrrhotite, a sulfide of copper are sources of sulfur also. However, pyrrohotite is not of commercial value unless the copper, nickel or cobalt associated with it is also of commercial value.

(mar' kah site)

There are other ores whose by-products are sulfur dioxide gas. Sulfur dioxide may be further treated to obtain raw sulfur or manufactured directly into sulfuric acid or liquid sulfur dioxide. The Frasch process was developed to extract the deep native sulfur found along the coast of Louisiana and southeast Texas. By drilling a well down to the sulfur beds and by placing three pipes, one inside the other, Herman Frasch was able to devise a recovery process. Superheated steam is forced into the sleeve of the outermost pipe to the bottom of the well. Compressed air is then sent down through the center pipe and the molten sulfur moves upward and out of the middle casing into hardening vats. These vats are very large--100 to 300 feet wide and several hundred feet long. The sides of the vats are built up to 50 or 60 feet as the sulfur hardens. Then this large sulfur block is dynamited into small pieces and shoveled onto railroad cars for transportation to processing plants.

The vast number of uses for sulfur require additional production methods other than mining to furnish necessary amounts to the domestic market. Purification of used sulfuric acid, recovery of hydrogen sulfide gas from some of the natural gases, and recovery of the sulfur dioxide gas released during the smelting process of lead, zinc, and copper ores are additional sources for sulfur.

There are estimates available that United States sulfur reserves may last over 500 years. Sulfur is a profitable export item today. Spain probably has the second largest production of sulfur with Canada in third place.

As mineral sources decline in availability, new alloys, other mineral substitutes and synthetics will of necessity be invented to take the place of some of our commonly used minerals that are in short supply. Many plastics and synthetics have already been found effective substitutes for a number of mineral uses, like teflon, styrofoam, and stylene. The inventive process will continue in the future.

Oil Supplies

Coal has nearly been replaced in some areas as a fuel by oil and gas. Oil and gas is thought to be decayed remains of once living matter much like coal. The remains of the organic matter combined to form large molecules of carbon atoms called hydrocarbons. These organic remains appear to have been deposited in a sluggish marine environment where the organic content is relatively high, forming a black mud called sapropel. Through a series of transformations, the sapropel is developed into petroleum and natural gas. A porous reservoir bed must be present in which the newly formed hydrocarbon can migrate to become trapped at some point and begin accumulating to form the "pool" of oil. Marine shales are the most important source beds. The oil shale reserves of Wyoming, Utah and Colorado hold about 50 times the known total reserves of oil in the United States. When the shale yields between 5 and 10 gallons of oil per ton of shale, the shale is defined as an oil shale. The oil shales are considered to be valuable oil reserves. Recently, the investigation of recovery of oil from these shales has received national attention, and research is under way to determine possible means of recovering the oil from the source bed. One project will utilize the heat of an atomic detonation deep below the surface to vaporize and crack the shale; upon cooling the hydrocarbons should condense and begin pooling, thus forming a reservoir of oil which can then be pumped to the surface.

sapropel: this word is derived from Greek and means rotten mud

Oil can accumulate at various points in the reservoir beds. One of the common points is at the top of an anticlinal trap (Fig. 1). Another common trap is the stratigraphic trap (Fig. 2); when the oil is stopped on its

SYMMETRICAL ANTICLINAL TRAP

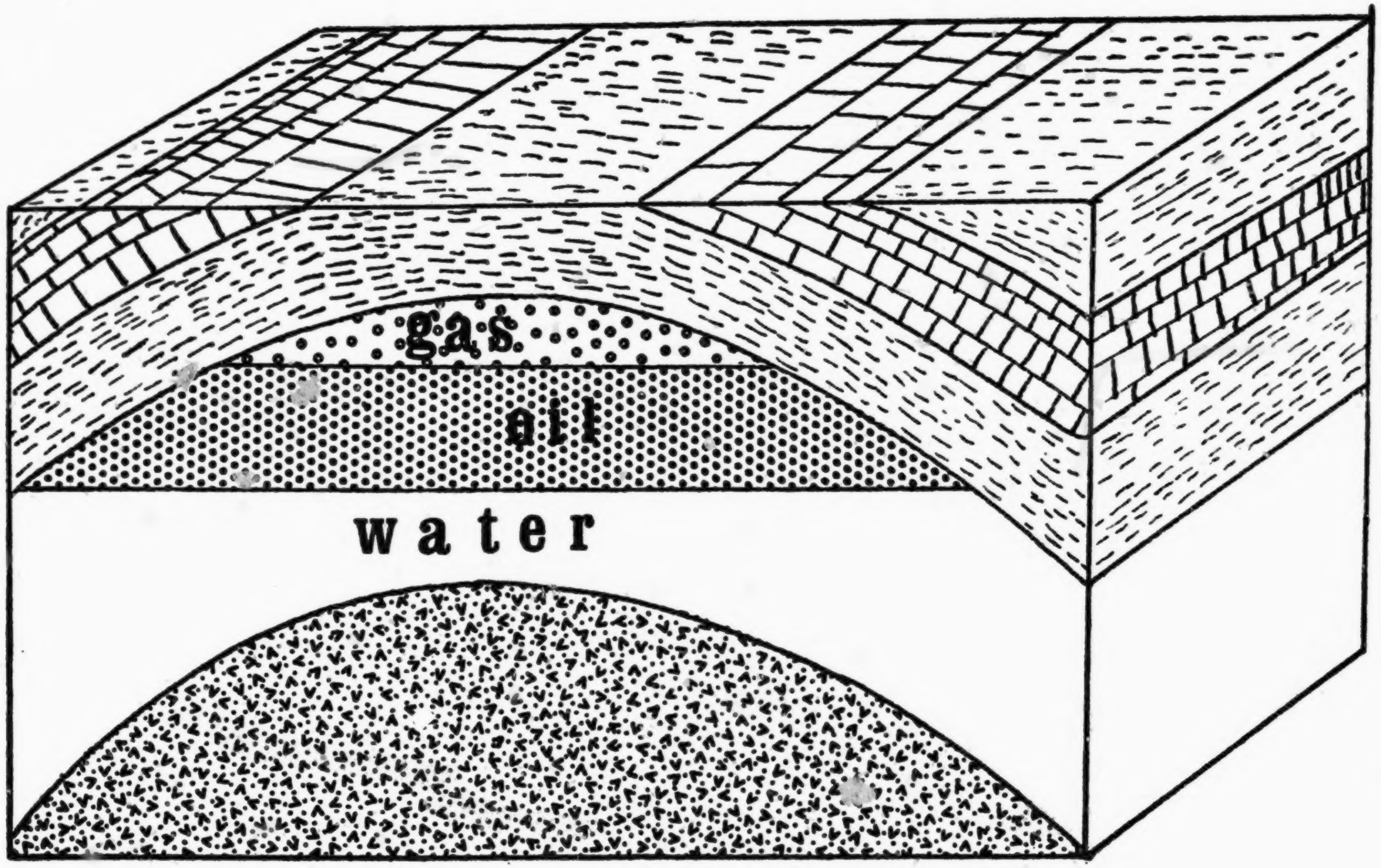
gas
oil
water

FIG. 1

STRATIGRAPHIC TRAP

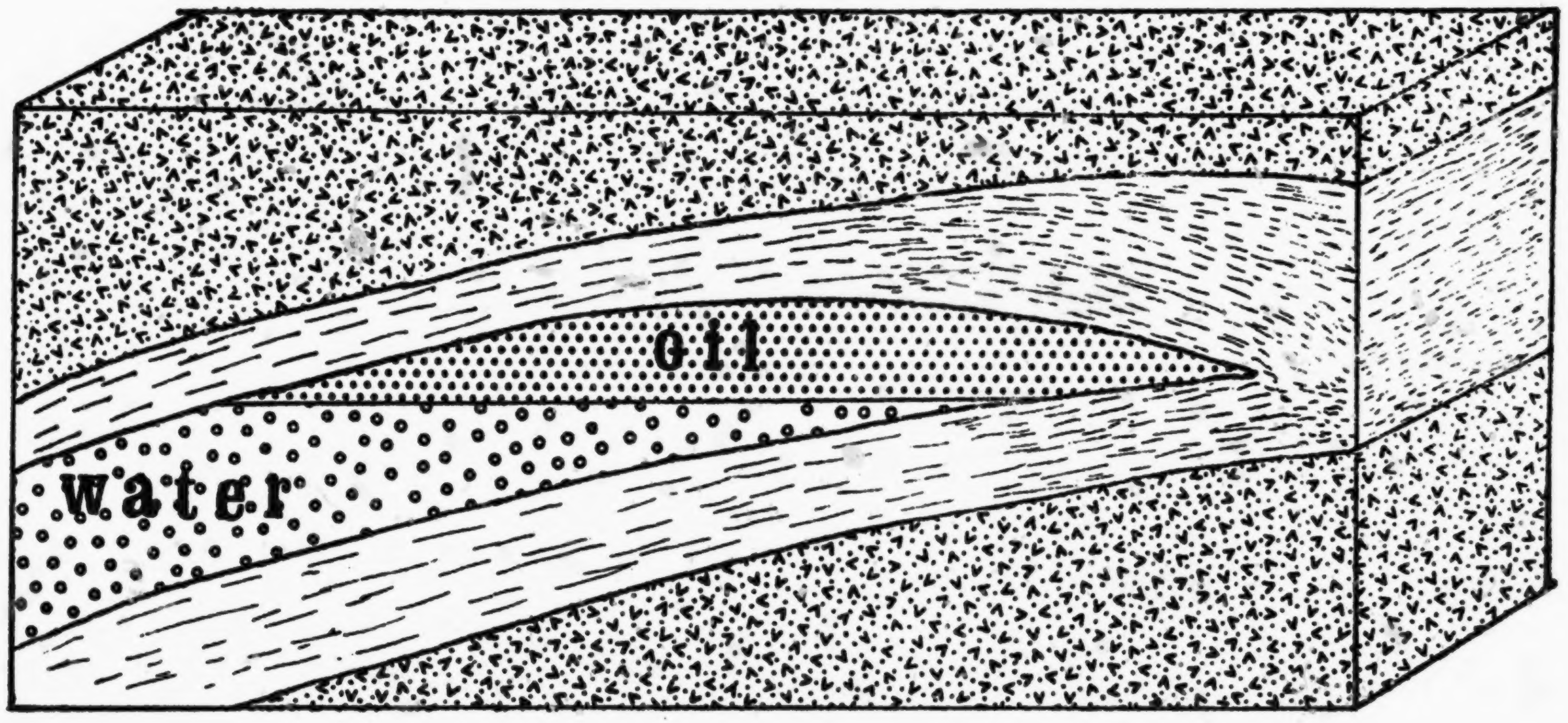

FIG 2

migratory course by reduced permeability of the strata through which the oil and gas is migrating, the oil gradually accumulates in pools. Water is frequently found in company with the migrating oil. However, because of the difference in densities, the oil, gas, and water separate into layers, the gas being located at the top and water at the bottom.

Early oil deposits were found by locating surface seepage and drilling to those locations. Hence, the early wells were shallow. Today, the wells may be drilled to several miles to obtain oil. After the surface seepages were exploited prospectors turned their attention to sedimentary rock formations that were shaped into anticlines that outcropped at the surface. The last few years seismic prospecting, core drilling and gravity methods have been employed to ascertain the locations of various hidden traps other than anticlinical ones. Some of the various types of traps are fault, unconformity, reef; and other miscellaneous traps are known. However, 80 percent of the known oil reserves are found in anticlinical traps in 58 percent of the world's oil fields. Petroleum is being extracted at the approximate rate of 147 billion gallons annually. However, even at this rate only about 10 percent of the world's oil has been produced.

When the first oil well was brought in by Colonel Drake at Titusville, Pennsylvania in 1859, the nearest market for the oil was in Pittsburgh, a hundred miles away. A most fundamental problem of transportation immediately confronted Drake. The first means of transporting oil to markets was by water. Barrels could be loaded on barges and floated to Pittsburgh; the cost of transportation, however, was excessive.

Sam Sychel, an oil buyer, upon visiting the new oil field, began considering ways to move the oil from the field to the newly laid railroad at Oil Creek more economically. He conceived the use of a pipe to transport the oil the five miles to the railhead. The pipe could handle 14,000 barrels of oil (42 gallons=1 barrel) for only $1.00 a barrel. The cost of handling one barrel for the five miles by water had been $3.00 a barrel with an 8-gallon loss of oil per barrel.

Since that first pipeline was laid, larger and larger pipes (up to 24 inches in diameter) and more complex systems have been laid. Use of the lines has expanded to include movement of not only crude oil but finished products too. The lines can handle many separate products at the same time without mixing. This is possible by keeping the line full and moving products in the line which have nearly the same density, as these products tend to mix less at their interface or contact zone. A sequence might include several grades of gasoline, with kerosene, furnace oils, diesel fuels then kerosene and again gasoline following each other in order through the line. The rate at which the material flows through the line is about one-half mile per hour.

After the "crude" is transported to the refinery the oil undergoes fractional distillation, an industrial process which takes advantage of the easy volatilization of the lighter hydrocarbons compared to the heavier ones.

Upon heating the crude oil the light weight hydrocarbons boil more quickly than the heavy ones; this "fraction" goes off as vapor and is condensed and collected. The first fraction to go off is naphtha and various types of gasoline between 104°F and 436°F. Upon continued heating other fractions are taken off until the petroleum is divided into many separate products. The thick tar-like residues left may be "cracked" to make gasoline, or treated in other ways to make asphalt, petroleum, coke, and miscellaneous petroleum chemicals. The light hydrocarbons may also be made into gasoline by a process called polymerization which joins together small chains of hydrocarbons into larger ones.

The many petroleum products in use today almost defy listing. The teacher should be able to have the students determine many uses of petroleum products from their own experiences.

Oil Law and Conservation

Laws have had to be devised whereby the person drilling for oil, the landowner, and the state in which the drilling takes place can peacefully settle disputes over rights and obligations. The laws are closely tied to economics of the individuals concerned and the conservation of the resource. Unlike many of the metals discussed earlier, very little reuse of this product is possible. One source for reuse, however, is used motor oil. Re-refining of used motor oil to remove additives and gasoline has been increasing the last few years.

The laws governing the production of crude oil have tried to (1) limit the rate of production to meet the current demand so very little oil will be wasted once it has been lifted above the ground, and (2) recover the maximum amount of oil possible from the reservoir.

Originally, the oil fields had their wells spaced so close together that only 10 to 20 percent of the oil could be recovered from the pools. However, by spacing wells properly, maximum yields (up to 80 percent) of the oil can be expected to be recovered. Spacing is usually defined by law, and may vary from state to state. Some wells may be spaced every 40 acres, but 80 to 160 acres spacing is practiced on some pools. The type of trap and the type of stratum help determine the optimum spacing for greatest efficiency. To obtain maximum recovery, gas or water may be pumped into the well to help maintain pressure levels necessary for maximum recovery of the oil.

Laws specifying the rights of the three parties, the driller, property owner and the state, began to be established just eight years after Drake brought in his 69½ foot deep well. The result was (1) the mineral rights belonged to the landowner, but (2) the oil belonged to the man that drilled the well. However, the landowner is paid a "share" of the income gained by the selling of the oil recovered from his lands. A state tax is levied on the number of barrels extracted from the pool.

There may come a time in the distant future where oil reserves may be depleted to the point that the cost of use might be prohibitive. Fortunately, many types of coal can be destructively distilled to produce the same products now made from petroleum resources.

Atomic power and electricity will eventually replace many energy uses made of petroleum products. Like minerals, petroleum products may have to be eventually replaced by synthetics and substitutes as the supply dwindles.

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MINERALS AND OIL

RESOURCE UNIT

Time Allotted ______

Unit Objectives

1. To gain an appreciation of our mineral and oil wealth and the usefulness of these resources.

2. To develop an understanding of the problems involved in managing our mineral and oil resources.

3. To develop a responsible attitude toward conservation of mineral and oil resources.

Concepts

1. Mineral and oil resources are limited. Wise use is necessary to continue receiving the benefits they provide us.

2. Man must develop new sources, substitutes, methods, and skills to meet his need for the goods and products manufactured from these resources.

3. Much of the power to perform work to improve our environment comes from the use of oil derivatives and some of our minerals.

Activities

1. Demonstrations and Investigations
   a. Corrosion
   b. Distillation of oil
   c. Destructive distillation of coal

2. Other Activities
   a. Make models
   b. Set up display of products
   c. Study methods of protecting
   d. Pipelines from corrosion

3. Field Trips
   a. Visit mine, refinery, oil field or other industrial plant utilizing the non-renewable resources.

MINERALS AND OIL

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. Minerals Presently Used by Man	
A. Raw sources	Film: The Earth: Resources in Its Crust
1. Location and types of local minerals of importance	
2. Mineral formation and deposition	
3. Limitation of mineral supply	
4. Simple identification of common minerals and their ores	
B. Use of raw supplies	
1. Industrial	
2. Agricultural	
3. Communications	
4. Power (coal, oil, uranium)	
5. Chemical products	
C. Economic value and conservation	Activity: Corrosion
1. Recovery of waste	
2. Development of economical extraction methods for low grade ores	Film: Copper Mining and Smelting
3. Reuse of raw material from cast off products	
4. Employment opportunities	
5. Power sources	
D. Future use of minerals	
1. Mineral and oil supply limitation creates need for new substitutes which will provide similar service	
a. Development of alloys	
b. Substitution of other minerals for those in short supply	
c. Creation of synthetics to replace mineral and oil products now in use	
II. Oil Supplies and Their Use	
A. Petroleum formation	
1. Location of source	
a. Anticlinal traps	
b. Stratigraphic traps	
2. Techniques of exploration, discovery, extraction and preparation	Activity: Distillation of used motor oil.
a. Drilling methods	
b. Pumping methods	
c. Transportation methods	
d. Processing methods	

- B. Uses of petroleum products
  - 1. Historical
  - 2. Modern
- C. Laws controlling production of oil
  - 1. Spacing of wells
  - 2. Proration
  - 3. Returning gas or water or both to the wells to maintain pressure

Film: Drilling for Oil

EQUIPMENT LIST FOR SUGGESTED ACTIVITIES

Shallow dishes

Beakers

Water glasses or petri dishes

Agar-agar

Nail

Copper wire

Zinc foil

Aluminum foil

Tin foil

Phenophthalein solution

Potassium ferricyanide solution

Pliers

Distilling column

Bunsen burner or electric hot plate

Used motor oil

SUGGESTED ACTIVITIES

Demonstrations and Investigations

1. Corrosion: When iron corrodes, the iron metal is said to oxidize. The corrosion of any metal is the result of the removal of electrons from the metal's surface to someplace else. This movement is an electrochemical reaction.

   If two hydrogen ions pick up the moving electrons released during the corrosion process, hydrogen gas is formed, of it electrons are picked up by a water molecule, a reaction occurs that produces hydroxide ions.

   Hydroxide ions indicate the presence of a base. Bases cause the indicator solution of phenolphthalein to turn pink. By using the chemical, potassium ferricyanide, in the presence of the corroding iron, a deep blue precipitate forms. Hence, these two chemicals, phenolphthalein and potassium ferricyanide, can be used as indicators for detecting the corrosion process under laboratory conditions.

   Materials: Shallow dishes, beakers, water glasses or petri dishes, agar-agar, zinc foil, phenolphthalein solution, nail, aluminum foil, potassium ferricyanide solution, copper wire, tin foil, pliers.

   Preparation of solutions and agar-agar:

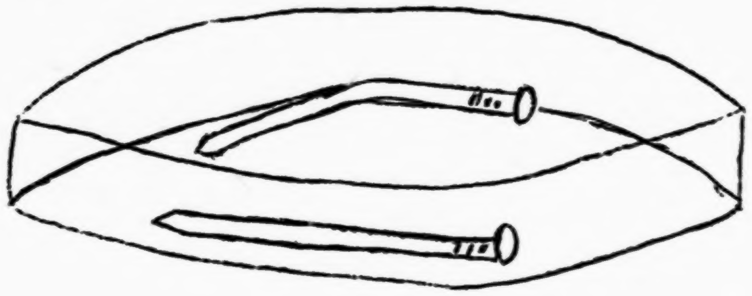
   1'. Agar-agar: The following solution when made produces a jelly-like material. Heat about 200 ml of water to boiling; remove from heat; add 2 gms of powdered agar-agar. Dissolve with constant stirring. It may be necessary to heat mixture again to complete dissolving process.

   When agar-agar has dissolved, add 5-10 drops of 0.1 Molar potassium ferricyanide solution; and add 3-5 drops phenolphthalein solution.

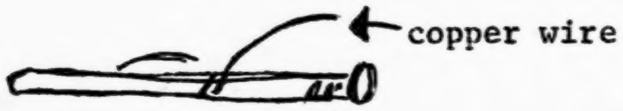
   2'. Phenolphthalein solution: Dissolve 1 gm of phenolphthalein powder in 40 ml ethyl alcohol; add 120 ml of distilled water.

   3'. Potassium ferricyanide, $K_3Fe(CN)_6$: Add 0.33 gm of material to 100 ml of water.

Procedure: Place a straight nail in one dish and a bent nail in the same dish, but on the other side of the bottom.



In a second dish place one straight nail with a $1\frac{1}{2}$" piece of copper wire wrapped around the nail a couple of times at right angles to the nail. Allow the excess wire to remain undisturbed.



Place a second nail in the same dish but with a piece of zinc foil wrapped in a similar manner as the copper. (The nails should not touch.) Pour the agar mixture into the two dishes with the nails so as to just cover the nails. Watch for 15-20 minutes and note changes. Observe the next day.

Helpful hints: Dish One -- The OH^- end of the nail will color the agar pink. The end that is losing the iron ions will turn blue. Dish Two -- Two metals that differ greatly in reactivity in the same liquid will form an electric cell. Such a cell will allow the electrons to flow to the less active metal protecting it. Hence, the use of one metal may help prevent the corrosion of another.

Therefore, what color is the gel next to the copper-iron set up? What significance is this? What would happen if aluminum foil was used on the nail? tin foil? Try them.

Questions to Aid Observations:
(1) What effect has bending on the tendency to corrode?
(2) What techniques might be used to prevent iron from rusting?

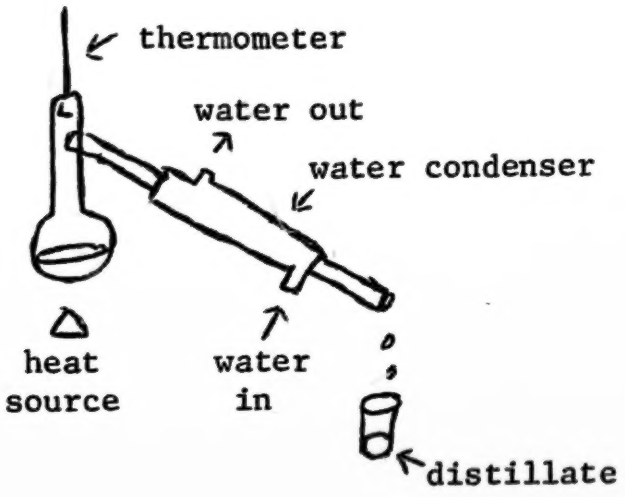
Additional information: Losses due to corrosion each year in the U. S. amount to $5 billion. But much of this could be prevented by:

(1) Painting the surface of the metal with paints, oil, or enamels, etc.

(2) Underground steel structures may be protected by electric current. (The steel is connected to the negative pole of a direct current source and the positive pole is connected to scrap or carbon rods, etc.)

(3) The use of sacrificial metals such as magnesiums and aluminum may be employed. The rods are connected to the steel and corrode first, thus protecting the steel. Galvanized hot water tanks employ this protection against corrosion of steel. Ocean vessels use magnesium attached to the hulls which lengthens the time interval between paint jobs.

2. Distillation of Oil: By obtaining used motor oil and setting up a distilling column, the used oil should be separable into two or more fractions. Set up the following way:



If a water condenser is not available, a long 3-foot glass tube may be substituted in its place. The air will cool the vapor sufficiently for condensation to occur.

Gasoline, water, and different grades of oil should be observed. The lighter the molecule the lower the temperature needed. Usually the fraction goes off over a rather short temperature range. A period of heating occurs then another fraction evolves.

3. Destructive Distillation of Coal: Coal products may be used as substitutes for oil products. If coal is available, especially lignite, benzene, toluene and miscellaneous "light" oils can be collected upon heating the coal in a closed container and condensing tne vapor. Use a set-up similar to that shown previously for distillation of oil.

4. Make models of drilling rig, refinery, pipeline set-up, etc.

5. Discuss the many products from oil and coal that are the same. Make displays.

6. Study ways pipelines are protected against corrosion.

Field Trip

1. If a mine, refinery or oil field is near, perhaps arrangements to visit the operation could be made with a little effort. Usually excellent cooperation is given to school groups.

SUGGESTED VISUAL AIDS

Coal Country, 18 min., AF.

Copper: Mining and Smelting, 11 min., color, EBF.

Drilling for Oil, 22 min., color, PD.

The Earth: Resources in Its Crust, 11 min., COR.

How an Oilfield Works, 28 min., color, AMPI.

Natural Resources -- Oil, 17 min., WPN.

Story of Petroleum, 10 min., EBF.

Treasures of the Earth, 11 min., color, CF or CWP.

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

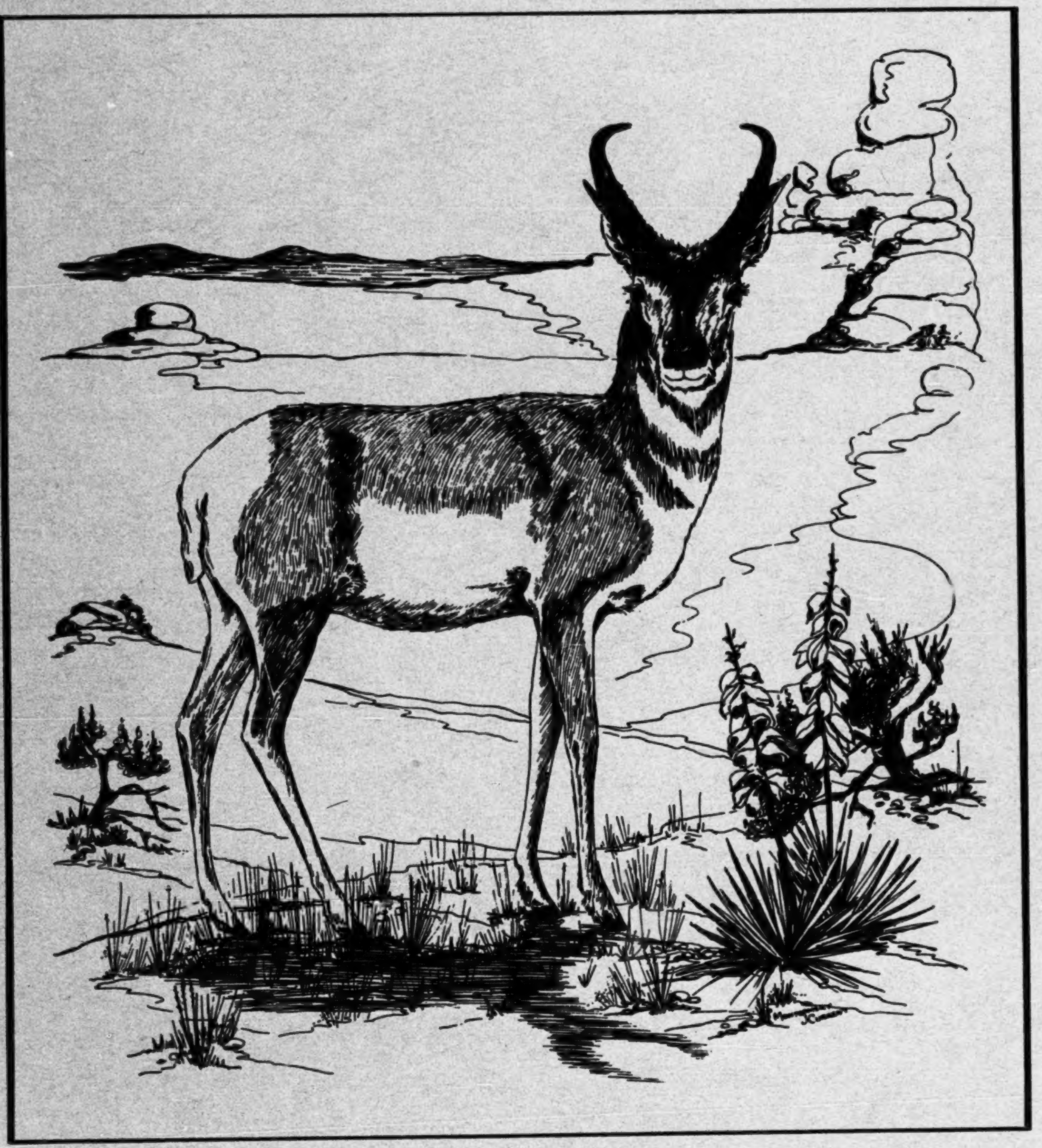
Chief, Office of Information
Bureau of Mines
U. S. Department of Interior
Washington, D. C. 20240

Information Officer
Geological Survey
U. S. Department of Interior
Washington, D. C. 20242

State Geologist
Wyoming Geological Survey
Box 3008
University Station
Laramie, Wyoming 82070

Wyoming Natural Resources Board
Supreme Court Building
Cheyenne, Wyoming 82001

CONSERVATION EDUCATION IMPROVEMENT PROJECT



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UNIVERSITY OF WYOMING
College of Education

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POLLUTION

TEACHER'S DISCUSSION

Depending on one's viewpoint, the age of the earth is about 3,000 million years. If we compare this time period to an hour, man has been on the earth for less than 2 seconds. During this brief time, nothing man has done to modify his environment will equal his capability to pollute the land, water, and air around him. Man's "technical advances" have progressed to the point where the air around him has become toxic enough to kill plants upon which he depends and to destroy his own lungs; the water is undrinkable; and the land's productivity is destroyed by undesirable chemicals and piles of refuse and junk.

pollute: to make dirty; to contaminate

Without favorable land, water, and air, man is destined to become exinct. Our brief existence on the earth does not provide any hopeful basis for suggesting that as an organism man will be able to adjust to a rapidly changing environment. Neither does the very fact that we have survived this long mean that the "technical advancements" modifying our land, water, and air have been well planned, rational, or even desirable.

Land Pollution

Litter

The problem of pollutants in man's environment is very real and very serious. On land the most conspicuous pollutant is litter. All of us have seen the tons of kleenex, soda pop and beer containers, food and candy wrappers, as well as other trash dumped along roadways, walkways, etc. Keep America Beautiful, Inc. has summarized the scope of this national disgrace as follows:

litter: a disorderly collection of rubbish

1. Each year littering costs our taxpayers around $1 billion. Street cleaning costs for urban areas is estimated to be $300 million annually. Another $100 million is needed for litter removal from highways. The U. S. Forest Service spends $3 million each year for sanitation and litter removal from national forests, while the National Park Service spends $2 million yearly for the same purpose on 190 parks, monuments, and recreation areas. At the Toledo, Ohio, City Zoo, an estimated 264 tons of litter are removed from the grounds each summer.

2. Each year, a home is destroyed or damaged every 12 minutes by fire starting in rubbish or litter. Litter caused fires represent losses in excess

of $22 million annually, as well as the tragic loss of human life. Broken glass and tin cans endanger swimmers. fishermen, and boaters, as well as domestic livestock on the range or in pastures. Automobile flat tires and blowouts from glass, nails, etc., threaten the safety of the motorist.

3. Litter is a health menace by creating breeding grounds for disease carrying rodents and insects.

4. Litter is unsightly and ugly, lowering property values and destroying the natural scenic beauty of an area thus driving away shoppers, tourists, and new industries. In 1965, the Bureau of Land Management estimated that 31,000 acres of public lands under its jurisdiction in the western states were covered with unauthorized garbage dumps, junkyards, or were heavily littered.

Individual thoughtlessness fosters littering and only the individual can prevent it. As a teacher, you can help combat littering by helping develop in each student an attitude of personal responsibility for the appearance of streets, highways, countryside, and any other landscape feature.

Chemical Pollutants

Less obvious, but much more insidious, are the toxic influences of the multitude of chemical compounds being dumped on our lands. These chemical compounds may be solids, liquids, or gases. As solids they may be in the form of: (1) dusting powders, (2) toxic bait pellets. (3) protective seed coatings, and (4) large long-lasting granules which release toxic materials for long-term control. Liquids are typically used as sprays in which toxic materials are: (1) dissolved in various solvents, (2) suspended as fine solid particles in large amounts of a fluid which is usually water, (3) emulsified in fine droplets of dissolved toxic materials suspended in large amounts of water or some commercial emulsifier, and (4) formed into finely divided droplets of toxic liquids becoming suspended in the air when released under pressure as a mist. Gases may be toxic gases or highly volatile solid materials usable in confined spaces as fumigants.

solvents: liquid capable of dissolving substance without reacting chemically with them

emulsified: a colloidal system consisting of one liquid dispersed within another liquid

Pesticides is a term used frequently to refer collectively to all of these toxic chemicals. Pesticides are not newly discovered compounds. The most widely used insecticide, DDT, was first produced in 1874, but was not used as an insecticide until 1939. Following World War II, many of the chemical compounds developed for chemical warfare against man were found to control insects which aided in greatly increasing crop yields. Throughout the world, the rapidly growing human populations create more demand for the elimination of any plant or animal which directly competes with man for his food and living space. Chemical industries have recognized the large potential market and have responded with a blizzard of low-cost, quick-kill chemicals readily available and easily used by industry, medical organizations, and laymen.

Production of pesticides in the United States increased from 124 million pounds in 1947 to 638 million pounds in 1960. In 1966, the overseas pesticide market was valued at $65 million and was expected to double in 10 years. In the United States in 1966, 110 toxic chemical compounds were being legally marketed. Of these, 88 were old, established compounds, and 22 were new compounds. Generally, these toxic chemicals may be grouped into one of five categories according to the class of organism they act upon. These very broad categories of toxic chemicals are summarized below and in Table 1.

1. Herbicides--used to kill all or selected parts of plants by direct poisoning or hormonal acceleration of plant growth rates.

2. Fungicides--usually copper-bearing or sulfur-bearing compounds used to control serious plant parasites such as rusts, mildews, and molds.

3. Insecticides--used to kill insects. Included are those chemicals which are used on such organisms as snails, crabs, etc.

4. Acaricides and miticides--developed because most insecticides are not effective on spiders and mites.

5. Rodenticides--chemicals with high toxicity applied to baits to control mammals, particuarly rodents and carnivores.

Thousands of these toxic chemicals have been tested as pesticides; but more often than not, the actual effects, beneficial or detrimental, can not be determined until a chemical is in use. Most of the toxic chemicals polluting our land have been introduced in the name of agriculture, public health, horticulture, and timber production. One can not overlook that beneficial effects have resulted from the use of pesticides. However, one should not overlook the obvious acute dangers to man since nearly all of those chemicals are toxic to humans, and little is known of: (1) the long-term effects on all other living non-target organisms from chronic exposures

Table 1. A condensed classification of major pesticides (Rudd, 1964).

Chemical group or action	Examples
Insecticides and acaricides	
Inorganic	
Arsenicals	Lead arsenate
Copper-bearing	Copper sulfate
Sodium fluoaluminate	Cryolite
Organic, naturally occurring	
Nicotine alkaloids	Nicotine sulfate
Pyrethroids (also synthetic)	Pyrethrum
Retenoids	Rotenone, ryania
Organic, synthetic	
Chlorinated hydrocarbons	Aldrin, aramite, benzene hexachloride, chloradane, DDT, endrin*, heptachlor, methoxychlor, toxaphene
"Dinitro" compounds	DNOC
Organic phosphorus compounds	Chlorthion, DDVP, diazinon, malathion, parathion, phosdrin, schradan, TEPP*
Carbamates	Sevin
Fungicides	
Mecurials	Mercuric chloride, "Ceresan"
Quinones	Phygon
Dithiocarbamates	Nabam, ziram
Others	Captan, thiram
Herbicides	
Contact toxicity	Sodium arsenite*, oils, "dinitro"
Translocated (spec. hormone types)	2,4-D; 2,4,5,T; dalapon; many others
Soil sterilants	Borates, chlorates, others
Soil fumigants	Methyl bromide, vapam
Rodenticides (mammal poisons)	
Anticoagulants	Warfarin, pival
Immediate action	Strychnine, sodium fluoroacetate, (1080)*, phosphorus, ANTU, thallium, endrin*
Other vertebrate targets	
Birds	Strychnine, TEPP*
Fishes	Rotenone, toxaphene

* Extremely toxic in very low concentrations

to pesticides used on target organisms; (2) the combining capabilities and effects of the multitude of toxic compounds inadvertently mixed together in nature by man. Some examples will serve to illustrate the specific dangers described. DDT auumulates in the fatty tissue of humans. It is not exactly known how DDT kills organisms, but it is known that it acts on the central nervous system. Residents of the United States now carry about 12 parts per million of DDT in their fatty tissues. If any individual loses weight the fat disappears, and the DDT is translocated to the brain and spinal cord tissues. Each year pesticides cause the death of an estimated 150 people. The State of California alone had 4,000 cases of non-fatal pesticide poisonings in 1960 (President's Science Advisory Committee, 1963). Such happenings are cause for concern, but of equal importance are the long-term subtle influences. Many of these chemicals can produce cancer at concentrations currently found in humans, as well as induce possible genetic damage.

Probably the most frustrating aspect of this foregoing problem is that as individuals we have only limited power to avoid exposure to undesirable chemical compounds. Certainly, we do not have to work where such exposures are a known risk. However, for most of us there is no way of exercising an effective choice when it relates to chemical residues on the food we eat, in the water we drink, or in the air we breathe. For example, only 1 to 2 percent of our foodstuffs are currently inspected by Food and Drug Administration inspectors. In one series of 800 milk samples collected randomly from all over the United States, 60 percent had illegal residues of chlorinated hydrocarbon pesticides (Clifford, 1957).

hydrocarbon: an organic compound containing only carbon and hydrogen

In the light of the lethal character of many pesticides, it is only natural that they have been quickly used to cope with and hopefully solve age-old problems of increased food production and public health. In their enthusiasm to get the job done, over-kill dosages all too frequently have been used first and evaluated later. In the fire ant control program which began in 1957 in 11 southeast states, over 2.5 million acres were aerially treated with dieldrin and heptachlor. Recommended pesticide dosages initially ranged from 1 to 2 pounds per acre and were finally reduced to 0.25 pound per acre in two applications. Besides having cost $15 million, the fire ant was not erradicated and has in fact reinfected many of the treated areas (Rudd, 1964).

In testimony before the Ribicoff Committee, the Executive Director of the National Aviation Trades Association testified about the abuses of suggested aerial application rates of pesticides. In one instance, 8 gallons per acre was adequate, but an enterprising chemical company suggested an application of 40 gallons per acre (Berg, 1964).

With this increasingly greater use of pesticides, their accumulation and disappearance from the landscape is of concern to all of us. Unfortunately, the pesticides used most widely are also very stable and accumulate chiefly in the cultivation zone of the soils (top 4-6 in.). The best known of these is DDT. In apple orchards, soils may accumulate 30 to 40 pounds of DDT per acre annually. In row crops such as corn and potatoes, the soils may annually accumulate 11 to 7 pounds per acre, respectively (Rudd, 1964). For over 50 years, arsenical pesticide residues have been observed accumulating in the soil. In the Pacific Northwest, some lands had as much as 1,400 pounds of arsenic trioxide per acre. Levels of arsenic in apples produced on such land became so high that Great Britain refused purchase of that fruit crop.

Usually the assumption is made that the pesticide residues in the soil breakdown into nontoxic components. This is not a correct assumption; and in the case of aldrin and heptachlor, which are widely used in grasshopper control, the soil residue components become more toxic than the parent compound. Aldrin disappears rapidly from the soil but leaves behind the more toxic dieldrin which decays more slowly than its parent material. Heptachlor leaves behind heptachlor epoxide which is far more toxic than its parent compound.

Further emphasizing the importance of these residues are the problems associated with secondary contamination by transport of these residues from treated areas to untreated areas. In northern Alabama, 15 streams were polluted by cotton insecticides; marine clam and oyster beds have been destroyed by insecticides sprayed on forest areas miles inland, and fish in the lower Mississippi River were killed by endrin entering the river many hundreds of miles upstream. Oysters exposed to 2 parts per million of DDT in the Gulf of Mexico grow more slowly than normal, and the DDT is concentrated in their tissues up to 25 parts per million. When these oysters are fed to fish, over half of the fish die within 48 hours (Science News, 1967).

The Future--Prospects and Choices

It is difficult to keep a proper perspective of the benefits and detriments of pesticides. Chemical pesticides have a use as a means of reducing undesirable organisms on a temporary basis. Pesticide chemicals should be selected on the basis that they will not produce toxic effects on other organisms beside the target species. The action of a toxic chemical pesticide has to be specific and of short duration. Chemical pesticides used in this manner are in effect "buying time" which will allow working out more effective, long-term solutions to the pest problem. Rudd (1964) discusses in further detail the serious biological and social consequences of continued chemical use. The hazards of toxic chemical pesticides are well enough documented in existing scientific information that we can not tolerate further delays in reducing their widespread use in our environment.

What actions might be taken to realistically cope with chemical pollution of our land? Herfindahl and Kneese (1965) have summarized three possible alternatives which obviously are best used in combination with each other:

1. More careful use of pesticides now in use. Users of these chemicals must be informed about the hazards of their use. These hazards not only include those involved with handling, but also those involving biological and sociological consequences. Improved state and federal regulations should be used to control chemical residues on food. The 1 percent of food now inspected could be raised easily. Since improper use results in illegal residues, this increased food inspection is an effective control measure. Also, the so-called eradication philosophy should be exercised only where chemicals are selective on new and geographically confined pests. Public justification should be required of all tax-supported pest control programs. Each justification should clearly describe the purposes of the proposed control program, the methods of control to be used, the hazards involved in the program and the economic or social benefits that can justify such hazards as well as the program costs.

2. Encourage the use of less persistent and more specific toxicants. Current legislation is not able to regulate use of persistent or broadly toxic chemicals. New regulations are necessary to strictly control pesticides requiring large doses of long lasting chemicals whose toxicity affects more organisms than the target species. Such control would specifically regulate programs using dieldrin, aldrin, and heptachlor. One suggested means

for control is by taxation of the user of persistent toxic chemicals when effective substitutes are available.

3. Encourage the use of biological control of pests. The use of chemical attractants to trap pests and the introduction of predators and parasites of pests show some useful applications. Cultural and faunal variability support more complex animals and plants which give pest populations less favorable environments. Agricultural practices where large areas have been planted with single crop species and where cultivation, irrigation, and fertilization are extensive, have not only created conditions favorable to man, but they have equally favored the pests.

Water Pollution

The daily water use in the United States has jumped from 160 billion gallons in 1945, to 355 billion gallons in 1963, and is expected to reach 600 billion gallons by 1980. The supply of water available is approximately 315 billion gallons, which means reuse of water is inevitable. The hazards involved are self-evident. The total Ohio River water flow is estimated to be reused nearly four times before reaching the Mississippi River. In Ohio, the Mahoning River is reused eight times before it reaches the Ohio River. In the field of space exploration, many people are a bit squeamish about use of distilled urine for water. It never occurs to these same individuals that over 40 percent of the water consumed today has previously passed through some human plumbing, household plumbing or industrial plumbing. The importance of having clean water is very obvious.

Degradable Wastes

Unfortunately, the water supplies in the United States and in most areas of the world are becoming more polluted rather than less polluted. The pollution materials in water can be classified as degradable or non-degradable, depending on their behavior when discharged into a stream. Degradable materials are organic wastes such as domestic sewage; industrial wastes such as trimmings and offal from slaughter houses, and organic chemical wastes. Degradation of these organic wastes in streams takes place in two ways. In clean water, oxygen supports certain bacteria which immediately feed on the organic wastes breaking them down into the inorganic components of carbon, nitrogen, and phosphorus which are basic plant nutrients. This degradation can only take place in the presence of oxygen and is termed aerobic degradation. The consumed oxygen in this aerobic process is replaced by new oxygen from photosynthesis of plants in the water and by gaseous exchanges at the air surface of streams, lakes, or ponds.

photosynthesis: process utilizing water, carbon dioxide, and sunlight to produce carbohydrates and oxygen

If the amount of organic waste is too great, the dissolved oxygen in the water may be exhausted. Degradation then proceeds more slowly anaerobically by bacteria which are capable of using organically or inorganically bound oxygen characteristically associated with nitrates and sulfates. As a result, gaseous by-products such as hydrogen sulfide (rotten egg smell) and methane (marsh gas) are given off. Waters in which anaerobic degradation takes place are characteristically black or dark brown in color, have a bad odor, and are not very aesthetic.

anaerobically: without free oxygen

The levels of oxygen in a stream or lake will vary according to the temperature of the water. If the water is too warm or too cold, the amount of oxygen present will be insufficient for aerobic degradation. Most sewage plant treatment systems utilize the aerobic degradation process by carefully controlling the water temperature, aeration, and amounts of organic wastes discharged into the sewage lagoons. Where the aerobic degradation is artificially manipulated, the plant nutrients become so abundant in the stream that they can cause excessive algal blooms. Depending on the kind of algae produced, they may give the water unpleasant tastes or cause it to smell very badly, or produce substances toxic to animal organisms.

Bacteria may also be classified as degradable pollutants. Typhoid, dysentary, and gastroenteritic bacteria die off rapidly in a self-cleaning stream or lake, and chlorine treatment finishes what aerobic degradation is unable to do. Viruses are not responsive to aerobic or anaerobic degradation and as such are serious epidemic threats in many areas having excessive organic waste discharge problems. The U. S. Public Health Service has isolated polio, infectious hepatitis, and 30 other live viruses from treated sewage effluents.

Non-degradable Wastes

Non-degradable pollutants are inorganic materials which essentially remain unchanged in the streams and lakes into which they have been discharged. They are not affected by aquatic bacteria and may make the water toxic, bad tasting, or undesirably mineralized. Also included here are those substances which may degrade so slowly that for all practical purposes they can be considered as non-degradable.

Typical non-degradable pollutants are: ordinary salts, such as alkali salts from many western irrigation projects and from freshwater distillation plants; heavy metals such as lead and arsenic from mining and industrial discharges; synthetic industrial compounds such as detergents, pesticides, phenols, paper pulp liquors, radio nucleides, and an undetermined number of combination possibilities.

Some of the typical problems of water pollution presented in the following can be found in nearly every state and every community where humans have taken up residence. Sewage treatment plants are at best only 90 percent efficient in degrading organic waste and are completely ineffective for most inorganic wastes. Unfortunately, approximately one-third of our cities have sewage treatment plants which remove only 35 percent of the organic wastes from the polluted waters (Clapper, 1963). In 1963, there was a backlog of 5,831 projects which were to cost $2.2 billion for municipal treatment plants and sewers. In that same year, industrial cleanup would have required 6,000 treatment plants (Clapper, 1963). At the southern end of Lake Michigan, from Chicago southeast along the shoreline to a point 10 miles inside the Indiana state line, there are 10 steel mills, 5 oil refineries and dozens of other plants like paper pulp and soap factories. Six of these major plants discharge a billion gallons of waste per day composed of 35,000 pounds of ammonia nitrogen, 3,500 pounds of phenols, 3,000 pounds of cyanide and 50 tons of oil (Hill, 1967). A large part of this discharge moves through the Grand Calumet River, the Little Calumet River, Wolf Lake, and various canals into Lake Michigan.

In shallow Lake Erie, pollution materials discharged into that lake have created an area 2,600 square miles in size ($\frac{1}{4}$ of the lake's surface), which has no oxygen in a 10-foot layer along the lake bottom. Large amounts of phosphates originating from domestic sewage and millions of pounds of waste detergents (each pound produces 700 pounds of algae) have caused a runaway growth of the algae. The decomposing algae and the already oxygen poor water have eliminated desirable fish from that lake.

As the water in Lake Erie flows through the Niagara River, it is further polluted to the extent that it will not even support anaerobic organisms in the vicinity of Buffalo. Counts of coliform-intestinal bacteria from the Niagara River water exceeds 1,500,000 per 100 milliliters which is 1,500 times the level considered safe for human contact (Hill, 1967).

Much discussion is given to the solution of water problems by using desalting plants. So far, cost and efficiency are the major considerations. Other side effects of desalting plants are not openly discussed. It has been calculated that the desalted water necessary for production of one pound of butter would require the removal of 400 pounds of salt. The question arises then, on whose land or in whose water will these salts be discharged? Even at coastal locations the dilution by ocean water would be insufficient to prevent destruction of many marine organisms, unless discharge pipes extended beyond coastal shelf limits.

The waste heat from proposed atomic desalting plants can be equally destructive. From one such proposed plant located at Point Conception, it has been calculated that the waste heat would raise the sea water temperature 18-23°F in a strip one mile wide and 40 miles long (Cons. News, 1964). The detrimental effect on many marine organisms would be disastrous.

Presently, some 500,000 organic chemicals are known and most are synthetically produced. Hundreds of these organic chemicals in varying concentrations are present in our treated water supplies. Because of costly identification, little is known about which compounds are present. To test for toxicity of various compounds, if they were identified, would cost between $50,000 and $250,000 per compound (Herfindahl, 1965). Some of these compounds have been studied and are extremely toxic in small amounts. For example, endrin, at concentrations of 0.005 of a pound in 3 acres of water, 1 foot deep, is highly toxic to fish.

Some effects of mining wastes on water are documented by Sigler (1967). In a study of the uranium mill wastes on the Animas, San Miguel, and Delores Rivers in Colorado, both radioactive (primarily radium 226) and non-radioactive materials such as sulfates, nitrates, chlorides, manganese, iron, lead, arsenic, and suspended materials are present. The long half-life of radium (1,620 years) constituted a long-term and continuous source of pollution.

half-life: the time required for half of the existing atoms of a radioactive substance to disintegrate

Atomic power developments are being proposed for many sites throughout the U. S. Like the desalting plants, problems of pollution from atomic power plant waste materials are potentially serious. Fuel rods in reactors of these atomic power plants accumulate nuclear fission products during power generation activities. These "hot" wastes include radioactive materials such as strontium, cesium, and carbon. At the Hanford, Washington, reactor this effluent is so contaminated with radioactive material that if one gallon per day were allowed to flow into the Columbia River, it would raise the radioactivity of the water above permissible levels. Presently, there are well over 50 million gallons of such reactor effluent in storage

reactor: an apparatus in which a chain reaction of fissionable material is is started and controlled

fission: (see page 12)

at Hanford. Currently, the only known practical means of disposing of such high-level radioactive reactor effluents is in costly storage tank "burial grounds" (Herfindahl, 1965).

fission: splitting of an atomic nucleus with the release of large amounts of energy

The Future--Prospects and Choices

Water courses have been traditionally used by man throughout every civilization to dilute and to remove his waste materials. Under increasing pressures of relatively constant water supplies and heavily increased demands, can this use of water for waste disposal continue in conflict with other municipal, industrial, and recreation uses? Many new kinds of pollution materials do not appear as floating or suspended materials in the water. As a result water quality treatment systems must be rapidly developed to remove or neutralize the adverse influence of these new, subtle waste materials.

Unfortunately, those individuals or groups responsible for the pollution of our water resource do not suffer from those polluted waters or the financial losses caused by their activities. Those bearing the detrimental impact of water pollution are the people living downstream from the sources of pollution. This automatically makes water pollution control a regional river system problem which respects no local or state boundaries. The establishment of interstate water pollution control commissions appear to be a major step towards regional management of water quality. New England states have had considerable success with this type of control. Members of such commissions would be appointed by the state governor and would include state officials concerned with pollution and human health as well as other individuals representing other important uses such as municipal, industrial, agricultural, recreation, etc. Because states have generally viewed their pollution of streams differently than those states further downstream, progress towards these ends has been slow. As a result, the Federal Water Pollution Control Act came into being in 1959, and has been further amended and strengthened during nearly every session of Congress.

The regional approach by states can be made to work if everyone concerned is willing to cooperate. Probably the most outstanding example of regional success is the Ruhr River system in Germany. Under regional design and operation, the Ruhr system achieves regulation of river flow by means of reservoir storage and release of water to augment low riverflow. Mechanical aeration of the water for increasing the self-purification of the river has been developed. Large-scale treatment of entire stream segments of the river to make the water fit for a particular use classification has been successfully undertaken to a degree never realized in the United States. Where pollution persists from a known source, that individual or organization is taxed according to the kind and extent of pollution material being discharged.

Air Pollution

For centuries, man has taken for granted the quantity and quality of the air enveloping the earth. Nine-tenths of this air is contained within an 11-mile belt next to the earth's surface. The quantitative demand for air by man is relatively small. The individual respiration consumptive activities require 30-60 pounds of air per day. Processes supporting man's daily needs in our modern society require an additional 2,600 pounds per day for such things as light, heat, transportation, food, refrigeration, ventilation of buildings, etc. (Bush, 1959). Normally continuing carbon, oxygen, and nitrogen cycles should perpetuate the quantity and quality of the air in a fashion similar to the hydrologic cycle perpetuating the water resource. Unfortunately, man-caused activities have interfered with these cycles and they are now seriously threatening the quality of the air available in many areas of the world.

While man began to pollute the air with his first use of fire, several relatively recent events were necessary to dramatize the serious degree of this air pollution. Four of these several events are summarized as follows:

a. 1930; Mause Valley, Leige, Belgium; 63 died from smog caused respiratory irritation; 5-day period.
b. October 27, 1948; Donora, Pennsylvania; 20 died and 5,910 (43 percent of the population) were ill from an accumulation of chimney emissions; 5-day period.
c. November 24, 1950; Poza Rica, Mexico; 22 died and 320 hospitalized from hydrogen sulfide which escaped from a sulfur recovery plant and drifted over the city; 20-minute period.
d. December 5, 1952; London, England; 4,000 died from accumulation of smoke and sulfur dioxide over 700 square mile fog bound area; 7-day period.

In addition, the complete devastation of vegetation by air pollution materials at Ducktown, Tennessee; Trail, British Columbia; Anaconda, Montana; and Redding, California, added emphasis to the seriousness of growing air pollution problems.

Primary Air Pollutants

Air pollution material can be divided into two categories: stable primary pollutants, and secondary pollutants. Stable primary pollutants include dusts, smoke, fumes, and droplets (aerosols) produced by mechanical and chemical means, as well as pollens, bacteria, fungi, molds, and viruses which adhere to the inert particles. As solids or liquids, primary pollutants consist of relatively large particles. They decrease visibility, dirty buildings, corrode metals, and obscure sunlight. A considerable decline of primary pollutants took place in the U. S. following the decline of coal burning fuel. Chicago's dust fall had decreased from 395 tons per square mile per month in 1928, to 43 tons in 1962. New York City has 60 tons falling on every square mile per month, while Pittsburgh, Pennsylvania has 30 tons. Poor visibility is one obvious result of primary pollutants in the air. In Pittsburgh, two years after initiating its smoke control ordinance, visibility improved 67 percent and there was 39 percent increase in days of observable sunshine. The reduction of dust in Chicago's air is not entirely related to reduced coal usage. The installation of electrostatic precipitators or similar devices have made significant gains. For example, Wisconsin Steel's precipitator collects 100 tons of iron oxides per day (two railroad gondola car loads) which would otherwise go into the air.

electrostatic precipitators: electric device placed in the smoke stack places a negative charge on the particles to permit capture of those particles on a positively charged plate

Secondary Air Pollutants

While the results of removing large particles seem spectacular over large areas, they can not be much source for comfort. First, with the removal of large particles, the job of removing the small ones becomes more and more difficult. Secondly, the shift to liquid and gaseous fuels has created pollutants that are much more difficult to control than were the old solid fuel types. This situation results in the creation of secondary air pollutants. Secondary air pollutants are the result of photochemical and chemical interactions between primary pollution materials. Combinations of these various pollution materials frequently creates a product more toxic than the sum effect of the separate pollutants (Herfindahl, 1965). Secondary pollutants are readily produced over nearly every area of the United States.

photochemical: when certain substances are subjected to light, light supplies the energy necessary for activation of the reacting molecules and a chemical change is produced

Air pollution knows no boundaries and nearly every city of 50,000 people or more and many cities of 10,000 population have serious air pollution problems. The family automobile is responsible for much of this type of air pollution. Automobiles exhaust air pollutants from the gas tank, carburetor, crankcase vent and from the tailpipe. An extreme example of this can be illustrated in Los Angeles County, California. There are in excess of 3 million automobiles in Los Angeles County which use over 6 million gallons of gasoline per day. These 3 million cars exhaust 8,050 tons of carbon monoxide and 1,650 tons of hydrocarbons each day (Herfindahl, 1965). These materials given off in unburned automobile fuels are irradiated by sunlight in stagnant air and the result is smog. To lesser degrees, similar smog problems can be found in Salt Lake City, Utah; Denver, Colorado; Missoula, Montana; and Casper or Cheyenne, Wyoming.

How dangerous are the influences of these smog materials? One thousand parts of carbon monoxide per 1 million parts of air will kill man very quickly. Bad headaches and dizziness result from 100 parts. Presently 50 parts is considered the danger level. Research in California indicates 30 parts for eight hours will seriously affect persons with poor blood circulation resulting from heart disease, arteriosclerosis, asthma, emphysema, or heavy smoking. Bagdikian (1966) summarizes a U. S. Public Health Service survey of air in Cincinnati, St. Louis, Chicago, Philadelphia, Denver, and Washington, D. C. during heavy traffic periods. Thirty parts per million levels of carbon monoxide were found 10 percent of the time with average levels inside automobiles becoming 21-29 parts per million. Other research with healthy Cincinnati firemen volunteers suggests more strongly the subtle but very serious impact of carbon monoxide. With well designed tests, no disabilities or slowed reactions were observed in these men at relatively low levels of carbon monoxide concentrations. However, despite a normal appearance, those volunteers breathing the carbon monoxide made more errors of judgment than those volunteers breathing pure air. With one percent carbon monoxide in the blood, judgment errors reached 10 percent. At the 20 percent level of carbon monoxide in the blood, the errors of judgment soared to 80 percent.

The hydrocarbons are known to cause a number of disabling and fatal diseases, but usually these diseases result from concentrations higher than are found in the air. Their influence is not clear and more work needs to be conducted to establish specific adverse disease relationships. It is known that they do combine with oxides of nitrogen to produce the brownish haze over cities. This eye-irritating and breath-taking pollutant most frequently results from the ozone oxidation of unburned fuel hydrocarbons. Ozone is produced by photochemical reactions of sunlight, organic substances, and oxides of nitrogen. Ozone is more powerful as an oxidizer than is oxygen and as such has caused damage

ozone: a blue gas, 1.5 times as dense as oxygen in the form of rusts estimated to total $25 million a year in 22 states. While the automobile is a major smog producer, a new producer is rapidly emerging, the jet airplane. Estimates indicate that one jet airplane exhausts pollution material equivalent to 6,800 automobiles.

One indirect aspect of air pollution from car exhausts is the deposition of tetraethyl lead on vegetation near roadways. Lead is an insidious element which may damage the liver, kidneys, and the brain. Studies of roadside vegetation in Denver, Colorado, and garden vegetables in Canandaigua, New York, and Washington County, Maryland, have been conducted by Cannon (1962). Significant amounts (5 to 20 times the expected background) of tetraethyl lead were found on the plants within 50 feet of the roadways and for as far as 100 feet downwind in the prevailing wind direction.

Next to carbon monoxide and the hydrocarbons, the sulfur oxides are the most abundant air pollutants. These gases produced by coal and oil-burning plants irritate the throat and cause serious lung damage. A study of 9,313 persons living in Nashville, Tennessee suggested that heart and circulatory diseases in persons over 55 were 100 percent higher in portions of the city having high sulfur readings. Even at low levels, damage can be expected. Sulfur dioxide levels averaging 0.01 to 0.02 parts per million in the air cause increased heart diseases, breathing difficulties, and impairment of brain functions. At 0.02 to 0.03 parts per million, the death rates from lung diseases increase, and plants are conspicuously damaged (Bagdikian, 1966). The critical degree of this type of pollution is self-evident. In 1964, the average level of sulfur dioxide expressed in parts per million were: Chicago, 0.18; Cincinnati, 0.04; Philadelphia, 0.08; St. Louis, 0.06; Washington, D. C., 0.05; Los Angeles, 0.01; San Francisco, 0.02.

One other air pollutant of considerable importance is fluorine. This is closely associated with steel mills and industrial developments such as phosphate processing plants. A characteristic result of fluoride poisoning occurred in Polk County, Florida. Phosphate plants in that county exhaust 7 tons of fluorides into the air every day. Cattle have died, crops were killed, barbed wire fences had their longevity cut from 20 to 4 years, truck garden crops were dangerous for human consumption, and glass was etched.

The retention of the sun's heat in the earth's atmosphere is correlated to a considerable degree with the amount of carbon dioxide present in our atmosphere. Small temperature increases have occurred here on the North American continent. To what extent these might be related to increasing carbon dioxide levels in the atmosphere remains as an unknown quantity. If future industrial growth proceeds as it is now, the carbon dioxide level could increase by over 50 percent of its present status by the end of this century (Herfindahl, 1965). An average increase of one degree over the entire world would drastically alter the world climate, with possible adverse influences on man. It would seem timely to conduct a thorough study of the relations between man's pollution activities, increasing concentrations of carbon dioxide in the atmosphere and shifting temperature patterns.

The Future--Prospects and Choices

We now have 88 million automobiles producing 350,000 tons of carbon monoxide, hydrocarbons, and nitrogen dioxide every day. The rate of automobile increases is over double the rate of our population increase. Any pollution reduction for cars now will be offset by the future increases in car numbers. New solutions to our transportation problems must be developed. The use of public subsidized trains, monorails, etc., may be one possible solution.

In general, much can be learned from Los Angeles County's successes with their air pollution program. They operate on the philosophy that no one has the right to poison the air of this country. Every industry coming into the county must have a pollution permit before it can build or operate. Twenty-five percent of the entire U. S. local spending for clean air is spent in Los Angeles County. In contrast, 16 states do not even have an authority concerned with air pollution. Ironically, it is estimated that the cost of operating a good local air pollution control program would be about 40-50 cents per person per year.

Lacking other effective controls, taxation of the polluter for every pound of pollutant material entering the air has had considerable success in Europe.

While not conclusive, there is strong evidence linking air pollution with high death rates from such diseases as cancer of the esophagus, stomach, and lungs; arteriosclerosis; etc. Unfortunately, public concern is not easily aroused when four-fifths of all air pollution may be invisible and largely odorless. Nevertheless, man's well being and survival are being seriously threatened. The rapidly expanding world populations are not only creating more complex pollution problems but are creating many more of them. Unless we can act soon, there is a very real possibility that no amount of technical knowledge will ever provide us with the opportunity we now have to successfully treat and protect our environment!

Literature Cited and Suggested References

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Bagdikian, B. H. 1966. Death in our air. Sat. Eve. Post. October 8.

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Herfindahl, O. C. and A. V. Kneese. 1965. Quality of the environment--an economic approach to some problems in using land, water, and air. Johns Hopkins Press, Baltimore, Maryland. 96 pp.

Hill, G. 1965. The Great and Dirty Lakes. Sat. Review. October 23.

Sigler, W. F., W. T. Helm, J. W. Angelovic, D. W. Linn, and S. S. Martin. 1967. The effects of uranium mill wastes on stream biota. Utah Agr. Exp. Station, Logan. Bull. 463. 76 pp.

RESOURCE UNIT

Unit Objectives

1. To convey an awareness of man's destructive pollution of his environment.

2. To develop an understanding of the relationship of pollution to man's well being and survival.

3. To develop an awareness of individual responsibility for preventing and treating pollution.

Concepts

1. There are many different forms of pollution on land, in water, and in the air.

2. There are methods of preventing, controlling, and treating pollution.

3. Each individual has a vested interest in and a responsibility for seeing that pollution is properly reduced and adequately treated.

Activities

Discussion springboards for class debate

1. Insecticides--good or bad
2. Water--desalting, a problem
3. Radioactive wastes--a dilemma
4. Atomic power--an effluent problem
5. Transportation--a killer system

Field trips and projects

1. City sewage treatment plant
2. Litter cleanup
3. Primary air pollutants
4. Unburned fuel
5. Gas combinations

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. Land Pollution	
A. Litter	
1. Cost of clean up	Activity: Litter clean up
2. Hazards created	
3. Loss of beauty	Film: Heritage of Splendor
B. Chemical pollutants	Activity: Pesticides--good or bad
1. Kinds of pesticides	
2. Problems of usage	
3. Alternatives for chemical treatment	Film: Natural Enemies of Insect Pests
II. Water Pollution	
A. Degradable wastes	
1. Aerobic degradation	Activity: City sewage plant visit, and effluent project
2. Anaerobic degradation	
B. Non-degradable wastes	Film: It's Your Decision--Clean Water
1. Organic	
2. Inorganic	
III. Air Pollution	
A. Primary air pollutants	
1. Solids	
2. Dusts	
B. Secondary air pollutants	Activity: Transportation--a killer system
1. Carbon monoxide	
2. Hydrocarbons	
3. Oxides of nitrogen	
4. Oxides of sulfur	
5. Fluorides	
6. Carbon dioxide	Film: Sources, Effects, and Control of Air Pollution

SUGGESTED ACTIVITIES

Discussion Springboards for Class Debate

1. Insecticides--good or bad
   a. We need more food to support our increasing human population; therefore, we must use insecticides to control insects that would damage or decrease our food supply.
   b. Insecticides are poisoning our environment to the extent that they are endangering the lives of our population through the food and water they use.

2. Water--desalting, a problem
   a. Water from the ocean can be made drinkable by removing the harmful salts at a desalting station.
   b. Salts removed from ocean water at a desalting station would contaminate the land or kill the animals and plants in the ocean near the station.

3. Radioactive wastes--a dilemma
   a. When man's food supply on the land is not sufficient, we can turn to the sea as a food source.
   b. We can not allow radioactive wastes to contaminate the land so they must be dumped in the sea.

4. Atomic power--an effluent problem
   a. When our coal and oil resources are used up we can use atomic power as an energy source.
   b. The use of atomic power produces radioactive waste that can not be allowed to contaminate our environment.

5. Transportation--a killer system
   a. Our nation's economy is dependent on our transportation system of cars, trucks, and jet airplanes.
   b. Cars, trucks, and jet airplanes are the major causes of air pollution.

Field Trips and Projects

1. Visit city sewage treatment plant and have employee explain process of sewage treatment.
   a. Collect water sample where sewage effluent is emptied into stream or river. Collect water samples above and below point where sewage effluent empties into river or stream. Collect any water plants or animals found in water above treated sewage discharge.

b. Set up study in classroom. Label water collected as follows: "Upstream from treated sewage discharge", "Treated sewage discharge". Place samples of life gathered upstream from sewage discharge pipe in each jar of water. If no native life was found use guppies, snails, goldfish or moss from any aquarium. Observe life in jars to see if they can survive in each of these samples.

c. Test part of water samples with bromthymol blue solution. Carbon dioxide from decaying organic material dissolves in water to form a weak acid. Water samples from various sources can be tested with an indicator of bromthymol blue. To determine whether or not the water is acid, place 3-5 drops of bromthymol blue in a 20 x 150 mm. test tube full of water. If acid is present the solution will turn green.

2. Visit an area where litter has accumulated. Time students as they clear some portion of the littered area. Measure the area cleared. Allow students to figure the number of man hours necessary to clear an area of this size. Ask students to agree on a fair price for their work per man hour. Figure the cost of clearing the area.

3. Place a clean white sheet of paper somewhere in the open where atmospheric dust can fall on it. Find a place where the paper will not be exposed to the wind. Make daily observations of the amount of dust collected.

4. Place a clean dish in a candle flame. The soot formed is a result of incomplete burning of the candle fuel.

5. Illustrate combining of gaseous vapors in the atmosphere. Place a few drops of concentrated hydrochloric acid in a small dish. Close by place a second dish containing a few drops of concentrated ammonia. DO NOT MIX THESE CHEMICALS. The gaseous vapor of these two substances will react to form a cloud of white, solid ammonium chloride.

SUGGESTED VISUAL AIDS

Movie films

Our Changing Environment, 17½ min., color, EBF.

*Heritage of Splendor, 18 min., color, AHP.

Woodland Manners, 19 min., color, USDA.

*It's Your Decision--Clean Water, 14½ min., color, AF.

Water--Let's Keep it Clean, 20 min., color, CFG.

Let's Look at Water, 22 min., b & w, CON.

Crisison Kanawha, 20 min., color, SF.

Chemical Conquest, 25 min., color, CON

Natural Enemies of Insect Pests, 27 min., color, UC.

Poison, Pests and People, 30 min., color, CF.

*Sources, Effects, and Control of Air Pollution; three 5-minute films, color, USP.

*Take a Deep Breath, 16 min., b & w, USP.

*Pall Over America, 15 min., b & w, USP.

* The Poisoned Air, 50 min., color, USP.

* With Each Breath, 28½ min., color, NYAP.

* Air Pollution--Everyones Business, 20 min., color, KSC.

* Free films

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

Chief, Information Branch
Division of Water Supply and Pollution Control
Public Health Service
U. S. Department of Health, Education and Welfare
Washington, D. C. 20201

Keep America Beautiful, Inc.
99 Park Avenue
New York, New York 10016

Director of Education
The Conservation Foundation
1250 Connecticut Avenue
Washington, D. C. 20036

Conservation Chairman
The Garden Club of America
598 Madison Avenue
New York, New York 10022

Director
Environmental Sanitation
State Office Building
Cheyenne, Wyoming 82001

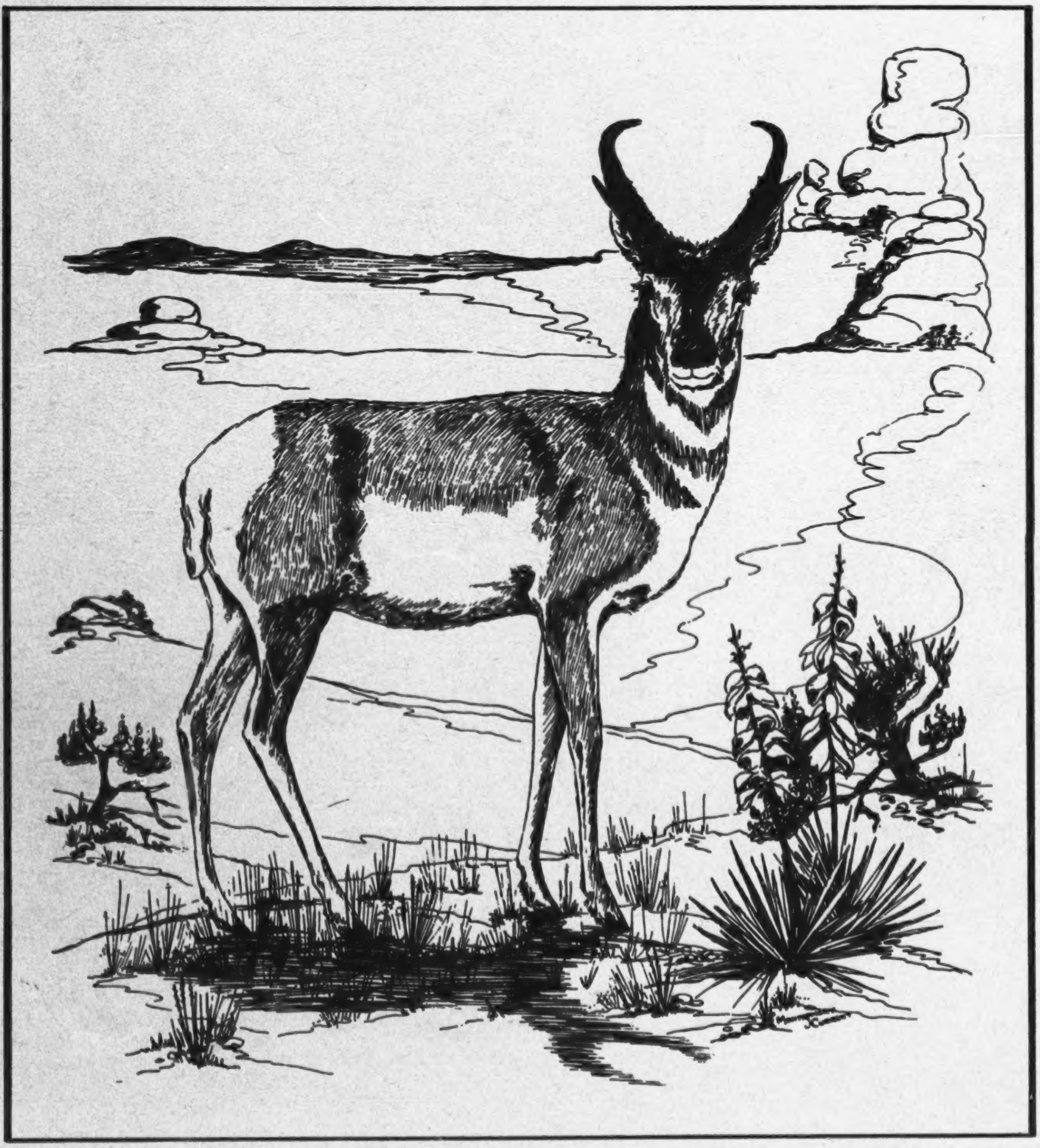
Dr. Wilson F. Clark
President
Conservation Education Association
Eastern Montana College
Billings, Montana 59101

Director of Information
The Izaak Walton League of America
1326 Waukegan Road
Glenview, Illinois 60005

Director of Education
National Audubon Society
1130 Fifth Avenue
New York, New York 10028

Chief, Conservation Education Division
National Wildlife Federation
1412 Sixteenth Street, N. W.
Washington, D. C. 20036

CONSERVATION EDUCATION IMPROVEMENT PROJECT



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UNIVERSITY OF WYOMING
College of Education

HUMAN RESOURCES

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HUMAN RESOURCES

TEACHER'S DISCUSSION

"In the last analysis the wealth of a nation is the quality of its human resources" (Ginzberg, 1966). The very term "resource" implies a reserve which may be converted into monetary wealth, property or products. Until the last decade little attempt was made to equate people with capital, although the concept appears to be a relatively old one. Sir William Petty in 1687 was probably the first economist to value a person as a special type of capital asset.

While concerned about the economic losses caused by the London plagues, he estimated the cost of moving people out of the city to safer regions, then estimated the value of an Englishman's production and the extra probability of his death upon remaining in the city and found the cost of moving a person could be a financial investment which would yield a return 84 times the original expenditure.

However, there has been a general reluctance in people to place a monetary value on human life. There are those that feel man should not be treated as capital because it removes him from a spiritual plain and reduces him to immoral levels; hence, the worth of humans is thus considered to have intangible values which lie in religion, love, and psychology. Nevertheless, in recent years, there has been an increasing awareness that expenditures which preserve or develop the individual will yield monetary returns that can be accounted for only by the increased productive capacity of the worker.

Traditionally, land, labor and capital have been considered as the conventional factors of production in an economy. However, these conventional inputs account for only 50 percent of the total output. The remainder can be accounted for only when improvements are considered in the quality of goods which the price does not reflect, improvements in efficiency of production due to better organization, improved techniques in handling goods, and increased services available through better trained personnel. Where before only physical capital (machines, buildings, goods, etc.) was considered within the framework of economic analysis, it has recently become increasingly apparent that in accounting for factors influencing the Gross National Product, Human Capital (although less tangible than physical capital) does exist and also operates in the economic structure and framework of production. Therefore, various types of investments in human beings must be included in the reference model to help account for the remainder of outputs left after conventional

Gross National Product: the total value of all commodities produced and services rendered by all the people of a nation during a specific period, usually one year

Human Capital: That capital produced by the human factor due to increased ability, training, education or desire inputs have been considered. Any type of expenditure that assists in increasing the production of the worker can be considered as an investment in human capital. Some of these expenditures could be related to health, education, migration, information, on-the-job training, special training, or law enforcement costs. Thus, when examining unnecessary loss of human lives either through accident, disease, war or starvation, not only must the psychic loss be considered but the economic loss also. True, the economic loss is extremely intangible since we are dealing with future expected output of the artistic, scientific, and judicial minds, or the skilled service personnel that are lost to society which might have seriously influenced the future development of society toward new and brighter horizons.

psychic: spiritual or pertaining to the human spirit

Populations and Migration

At the present, the West, specifically the West Coast, is the most rapidly growing region in the United States. It is increasing in population nearly twice as fast as any other region. The Negro population in that area has increased 59 percent compared to a national increase of 11 percent in the Negro population for the last decade. It might be interesting to point out that during this same period, no increases were found in the South. The Northwest, however, showed an increase of 24 percent, while the North Central portion picked up 23 percent, indicating the southern region has a Negro birth rate that keeps pace with its migration rate. Apparently, greater opportunities for better conditions exist elsewhere for the Negro than in the South.

The farm population fell during the same period from 12 percent to 9 percent leaving approximately 12 million persons on farms in the United States. In a recent report critized by Rep. William H. Harrison, R-Wyo., the National Advisory Commission on Food and Fiber maintains "agriculture can not provide a decent living for more than one million farm families." In 1965, a plan to remove 2.5 million farm families from agricultural communities was proposed. It was suggested that money for moving expenses be made available to help provide incentives to relocate the families in metropolitan areas. In view of already overcrowded conditions in most cities, Rep. Harrison raised the question, "Will they [the farmers] become nothing more than unwilling applicants for the welfare role?" Before any such measures can be placed into effect, the careful examination of the various costs involved must be assessed to determine if a return may be expected from such a proposal if carried out or would a loss accrue in terms of output of human capital and farm commodities.

accrue: to arise in due course

Large cities are losing population to the surrounding suburbs at a steady rate. Filling the vacancies left by the exodus in those cities are those citizens that do not earn substantial amounts and can not move elsewhere. These areas fast become ghettos, taking on slum appearances and characteristics that generate frustrations and dissatisfactions which ultimately sow the seeds of hatred and breed violence toward society in general.

According to Sisk (1960) 25 percent of our population changed addresses in the 1950's. It is now estimated that nearly 20 percent of the population is moving each year. High mobility seems characteristic of two groups, the unskilled or semiskilled and the highly educated. The more education one has the greater the chance of moving because of the nature of the job (usually highly salaried are not as permanent in terms of location). Many companies move their trained personnel from time to time and relocate them according to their specialities and the needs or requirements of the company. The unskilled or semiskilled frequently experience lay offs and tend to shift locations accordingly, although their moves are not as apt to be as far from their original location as the more specialized experience.

Regional shifts in populations are usually responses to dissatisfaction in conditions in that region: unemployment, poor living environment, low pay, lack of promotional opportunities, and excessive debt. One factor or a combination of these factors can greatly influence the individual into changing his location. Although it requires an expenditure to move, the cost of the migration to improve individual economic benefits may be treated as an investment provided the migration leads to future productivity of the migrant.

All expenses such as lost earnings while searching for work, travel expenses, and costs in learning a new job can be tabulated rather easily and considered as a portion of the investment. The psychic costs are less easily assessed. Nevertheless, they vitally influence the function and efficiency of the individual while adjusting to his new job situation and environment. Loss of friends, family, and familiar surroundings may be partially compensated for, however, by obtaining new friends, enjoyment of the new area, and greater job satisfaction.

Computations for determining the cost of the return from the migration can be estimated by comparing the living costs and increased earnings in the new area with those in the old area had the move not been made. Net gains may accrue to the individual either as a consumer or as a producer.

The migrant, of course, does not reap all the benefits of the migration, nor does he shoulder all the burden of the cost of the migration. Health costs, recreational costs, educational expenses, and sometimes transportation costs are borne by the company to which the migrant has moved. The company must compare these costs to the benefits received by the company after the worker has begun to yield a production which returns an investment to that company. If the worker moves before that investment brings a return, the company suffers a loss on the investment and another company may benefit. It, therefore, becomes important for a company to hold personnel, as long as possible, in order to yield the greatest return from their investment.

Sjaastad (1962) records, "The observed future earnings differentials between what the migrant is earning and what he would have earned had he not moved can not be attributed to migration [only] but must surely be divided among other factors which affect the migrant's productivity in his new location." Thus a discussion of investments in education, health, and law enforcement logically follows.

Development of Human Resources

The development of human resources constitutes the improvement of motor skills, formulation of proper attitudes toward society, improvement of mental competence and best utilization of the individual's strengths and talents for a more productive society. The development of an individual requires an expenditure either by Federal, State, or Local government, or the cost must be borne by the individual, the immediate family, industry, or business. This expenditure may be considered an investment if that expenditure increases the financial prospects, creativity or productivity of the individual above that which the individual would have shown if left to the same circumstances without change. However, the return on the expenditure must be considered as a long-term return and not one which will mature in a few short years. It is the life-time productivity of the individual which must be considered. Any untimely reduction of life span for an individual, therefore, reduces the amount of return which could ordinarily be expected, from the investment. The protection of the individual becomes increasingly important in order to permit a maximum return on the investment.

If executed properly, education can elevate a population's skills, stimulate creative attempts, and improve techniques and products. Besides increasing an individual's earning power, there are benefits from education which do not lend themselves to monetary valuation. Education can greatly enrich the lives of people by broadening their experiences. It has been shown by Campbell, et al. (1960) that with the increase of the educational level of the individual, there is increase in the sense of responsibility toward good government which is the strength of a democracy.

Kendrick (1956) says that of the 3.3 percent of the average annual rate of growth in real product from the turn of the century to 1953, only 50 percent of the productivity can be accounted for by increased use of conventional inputs. He further maintains economists are not considering the services of immaterial capital (human capital). He contends immaterial capital is cultural and is largely found in the technical knowledge of individuals as a result of investment in education and research. Services are manifested through the application of technical know-how by individuals involved in production or through instruments of production.

real product: National Product

Investments by Federal Government in higher education as early as 1785, were designed with a practical purpose to aid farmers by establishing land grant agricultural universities. Returns on such investments are readily seen. Later the legislation was provided to assist in the reduction of unemployment in the 1930's, through college-classroom construction. Despite this, until the National Defense Education Act of 1953, legislators and citizens demanded some evidence that support of higher education was a profitable investment. Even today, economists are attempting to determine what financial returns are occurring from educational inputs and what effects these inputs have on economic growth. The results of these studies are yet too uncertain to make specific statements. However, the growth of financial investments in education are continuing at a rapid rate. Initially at least the value of education seems apparent. Expenditures more than doubled in the decade of the 1950's. During the turn of the century there has been four times the expenditure on education that there has been on physical plants and equipment.

At present we are spending $8.1 billion on educational activities, $3.83 billion are for grants, $90.5 million is administered through the National Defense Education Act, and $2.0 billion are set aside for higher education. Vocational education expenditures rose from $0.7 million in 1925 to $5.4 million by 1965. The public schools are spending $25.8 billion a year of the taxpayer's dollar to improve national educational levels. In 1965, United States legislators enacted a program which would provide $980 million over a five-year period. The additional services that were to be provided for include such programs as Head

Start (for preschool children), Upward Bound (precollege students), the Higher Education Facilities Act, Elementary and Secondary Education Act, and assistance to communities with school construction plans. (At the same time the federal contributions supporting school milk and lunch programs were reduced and was an unpopular feature of this legislation.) The money obtained under these various programs is primarily directed toward public schools in poverty areas. However 95 percent of the nation's 3,100 counties are eligible to receive aid. Equipment purchases and program assistance may be obtained in educational radio and television, library improvements, textbooks, before and after school programs, etc. Educational centers benefiting the entire community can also be provided through this legislation.

In an analysis of the value of education, it is useful to view education as an industry which uses resources and produces outputs.

Economic gains to individuals from education are large. Two methods of analysis which may be used are yearly incomes and unemployment rates. Additional education seems to increase the yearly earning power of the individual and reduce the liklihood of unemployment. Weisbrod (1966), however, points out that there is danger in interpretation of the data which illustrates the value placed upon additional education, as other factors are involved. The individual that dropped from high school may not actually have been able to increase his income. The characteristics which caused him to drop out of school are generally the same ones which might prevent him from pursuing a job opportunity to its fullest. It has been observed that students continuing their education are generally more able, ambitious, inquisitive, and come from environmental backgrounds favorable to the learning process. Further, family connections to better job opportunities are usually greater. Therefore, in any direct analysis, the benefits attributable to schooling itself are difficult to separate from these other factors which also contribute to the monetary return from additional education.

Of course, jobs are not created by education alone. Rather, the individual is elevated in skills which keep pace with employment requests. Nevertheless, college graduates between 25-34 earned $12,269 in 1958, as compared to $6,295 for high school graduates, and $4,337 for elementary school graduates of the same age bracket. Education statistics further indicate that there were still 22.5 million people, 18 years and older, with less than an elementary education in 1965. The lack of education leads to poverty, unemployment, and a stifling of the intellect. Drop outs are concentrated in occupations having low incomes and high unemployment. Improved guidance services and professional consulting at early ages might assist with the drop out problem and increase to new levels the potential of the population. Government programs such as Job Corps are attempting to help alleviate the difficulties facing the jobless, unskilled, and poorly educated. According to Kiker (1966) a number of writers have estimated that between 21-40 percent of the growth of the National Income between 1929 and 1956 was a result of increased educational levels of the populations.

Protection of Human Resources

Health

The average life expectancy rose from 47.3 years in 1900 to 70.2 years by 1965. The birth rate steadily increased to a peak of 24.6 live births per 100,000 population in 1955. Since that time a steady decline has been noticed. The death rate has not changed greatly in the last 27 years; in 1940 it was 10.8 per 100,000 and in 1964, 9.4. During the last decade the rates for the four leading causes of death have not changed. Heart disease accounted for 33 percent of all deaths. Malignant neoplasms accounted for 16 percent, while vascular lesions caused 11 percent and accidents 6 percent of all deaths. As a result of the constant death rate and the natural increase of the population, plus the several thousand immigrants which come to the United States each year, by 1968 the population will have reached the 200 million mark. The average age of the population is declining, but at the same time people are living to older ages and become less productive. This places more stress upon the working groups to maintain those less productive old age groups.

malignant neoplasms: cancers of assorted types

vascular lesions: injured circulatory tissues

The death rate for malignant neoplasms of the respiratory system has increased by about 40 percent in the last 10 years. Death from motor vehicle accidents has been increasing since 1961, while mortality from non-motor accidents has decreased slightly during the same period. The death rate for influenza and pneumonia has fluctuated over the last 10 years but is 12 percent higher now than in 1956. In 1965, the death rate for automotive accidents alone amounted to 48,900 or 25.2 per 10,000 population. Nearly 50 percent of all deaths due to accidents were attributable to automobiles. There are about 22 thousand suicides each year and 10 thousand homicides. State and county mental hospitals handle 452,000 persons daily.

The spiritual loss felt by families through needless death and mental illness can not be evaluated in monetary terms. Yet, a monetary loss might be estimated in terms of what that individual might have contributed to his family and society had he lived or remained productive. The cost might be calculated in terms of insurance payed out, medical expenses incurred by the family, property damage, etc. Costs due to accidents alone have resulted in an annual loss of $10.7 billion with traffic accidents costing $5.8 billion (nearly one-half of the cost of all accidents). Some of these accident costs can be reduced. In a recent study of highway accidents in Wyoming by Hooker (1966), it was found that for each extra dollar spent on the Wyoming Highway Patrol, highway accident costs were reduced by $12. This amounts to more than a 1,000 percent return on the investment.

In 1966, $41 million were provided as grants by the government to train specialists in understaffed health services, to support various types of programs in research, to aid in studies on alcoholism, to improve health services, to help modernize hospitals, to assist in reorganization of the Public Health Service and for other additional contributions toward State and Municipal Health Services.

More funds will be needed and should be provided in the future to improve and maintain mental health, physical health, and reduce accidents. Gains are being made to protect productive lives so an individual or a family will not only benefit, but all society will benefit as well.

Research is currently being undertaken to estimate how much the amount of increased output over a period of time may be the result of health investment.

Various cost estimates have been made concerning what losses may cost from poor health and accidents based on wages lost due to illness, sick leave pay, etc. Mushkin (1962) says $700 million is lost through health disability as based on 1959 income tax deductions. Mushkin and Weisbrod (1963) state the total lifetime health investment in the 1960 work force amounted to $204 billion. According to Kiker (1966), T. W. Schultz estimated $535 billion had been expended on the education of the 1957 work force. If the yield on educational investments were 21 to 40 percent over the years 1929 to 1956, and if that portion of money invested in health produced the same yield on the return as educational investments, then 8 to 16 percent of the growth of the national product could be attributable to health investments over that same period.

Crime

In 1965 the value of goods stolen in robberies, thefts and larcenies amounted to over $1 billion. From 1960 to 1965, according to the F.B.I. Uniform Crime Reports, serious crime increased by 46 percent compared to a population increase of 6 percent. Arrests of persons 18 years and under accounted for a 47 percent increase in serious crime. Suburban areas showed the greatest increases in arrest in 1965, up 5 percent. However, authorities point out, the crime increase is not the result of more criminals but rather increased victim risk. Less than 5 out of 100 young people are involved in police arrest, but there are many repeat offenders. For example, in a case study of criminal records and offenses, it is shown that after the first leniency, suspended sentence, parole, probation, conditioned release, there was a history of an average of three new arrests.

Five serious crimes occur each minute. A burglary occurs every 27 seconds, and an auto theft takes place every minute. These offenses against ourselves are costly. It is easier to prevent loss of life and property by crime than to try to correct the loss later. Recently President Johnson directed a commission to begin investigating means for reducing crime rates in the United States.

The cost of the problem and yield on the investment will undoubtedly be a factor in appropriation of government funds to reduce crime costs at a later date.

The values of investments in humans and the development of an analytical framework to determine how best to invest that money available for such purpose has been summarized by Kiker (1966) as follows:

(1) The economic aspects of education both formal and on-the-job, health services, information, and human migration may be usefully investigated within the human-capital analytical framework.

(2) An estimate of human-capital values may be useful for an investment criterion; that is, the human-capital analytical framework may be used to determine the internal rate of return obtained on human-capital (or a component of human-capital) formation which may then be compared with prospective rates on alternative investments.

(3) Rational population policies should involve assessment of the human-capital value of additional people.

(4) Assessment of highway construction, flood-control, and other public projects may be enhanced by information of the human-capital value perserved through such expenditures.

(5) Monetary evaluation of human beings may alert the public and governments to the need of human-resource development and conservation.

(6) Courts and compensation boards should employ the human-capital concept in making fair decisions in cases dealing with compensation for personal injury and death.

Certainly the capital analytical framework might be usefully applied to the question of investment in acquired skills.

A strict adherence to the human-capital analytical framework by policy makers, however, might lead to absurd answers to such questions as the following:

(1) Should society discourage advanced studies by women unless they can give assurance that their "human capital" will be utilized even after marriage?

(2) Should society discourage the training of teachers, who appear to receive a low monetary yield on their investments?

(3) Should society discourage medical care or financial aid to individuals beyond retirement age (that is, to individuals who are fully depreciated as human capital) since no monetary yield would be forthcoming?

(4) Should society force human migration from depressed areas when the result would lead to an unhappy (although presumably more productive work force)?

(5) Should society discourage disease eradication when the internal monetary rate of return on expenditures for such eradication is lower than the return on alternative business investments?

Dr. Kiker says the answer to the above questions is "No".

Is Dr. Kiker's position correct or are there other alternatives?

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HUMAN RESOURCES

RESOURCE UNIT

Time Alloted ____________

Unit objectives

1. To develop an understanding that humans themselves constitute a natural resource that can be conserved and used like other conventional resources.
2. To gain a fuller realization of the value of human life with respect to health, education, government, and law enforcement.
3. To develop an appreciation for the magnitude of the tasks ahead for society to care for its people which compose it.

Concepts

1. The quality of a nation's human resources has a direct bearing on its wealth.
2. The education of the mind of man, the development of his creativity, the protection of his health and life constitute an endeavor to develop a greater social organization and to generate greater amounts of wealth for his own purpose for a more abundant life.

Activities

1. Primary and secondary education costs.
2. Professional and trade training costs.
3. Welfare support costs vs education costs.
4. Retraining costs.
5. Crime, costs of imprisonment, and prevention.
6. Financial return to State for education expenditures.
7. College education costs.
8. Repayment of education costs and retirement.

HUMAN RESOURCES

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. The place of man in the economic growth of a nation	Film: Wastage of Human Resources
A. Conventional factors of economic growth and the gross national product	
1. Human capital formation	
2. Types of investments in human resources	
B. Populations and migration	
1. Causes of population changes of various regions of the U. S.	
2. Causes of movement of Negro populations	
3. Causes of farm population shifts	
4. Causes of city population shifts	
5. Costs and benefits derived from migration	
II. Development of human resources	
A. Discovery of talent and its training	
1. Physical development (skills)	
2. Mental development	
B. Investment in education	
1. Government spending	Project: Welfare support costs vs education costs
2. Private spending	
3. Returns on investments and the growth of the national product	
C. Expected benefits of education as based on statistics	
1. Earning power increases	
2. Productivity increases	
3. Broadening characteristics of the educational experiences	
III. Protection of human resources	
A. Productivity and health	
1. Life expectancy and depreciation of man	
2. Birth rates versus death rates and the growth of human populations	
3. Health statistics	
a. Leading causes of death and disability	
b. Cost of poor health to industry	
c. Cost of loss of a productive worker to society	
d. Cost of accidents to society	

B. Crime and law enforcement
    1. Lost goods and life due to crime
    2. Moral decline
    3. Extra expenses to society

Project: Crime, cost of imprisonment, and prevention

SUGGESTED ACTIVITIES

1. Primary and secondary education costs.
   Suggest students find out the amount of money invested in their education to this point by society.
   (The amount the community spends on buildings, teachers, books, etc., per year divided by the number of students in school and multiplied by the number of years the student has been in school.)

2. Professional and trade training costs.
   Students might choose a profession or job in which they are interested. Ascertain the amount of money necessary to educate for this job. Investigate probable returns on this investment in terms of salary per year times the number of productive years.

3. Welfare support costs vs education costs.
   Find out the amount spent on a non-productive person in terms of welfare support. Figure the amount needed to educate this person to support himself and his family. (It will be necessary to agree on a family of a specified size.) Compare the amount needed to educate a person to the amount necessary to support him on welfare.

4. Retraining costs.
   Compare the amount of money necessary to retrain an employee whose job has become obsolete to the amount of unemployment compensation he might receive.

5. Crime, costs of imprisonment, and prevention.
   Investigate crime in relation to the education and background of the criminal. Find out the cost to the state to imprison one person for a year. Discuss the types of investments that might prevent crime.

6. Financial return to state for education expenditures.
   Figure the amount of return to the government, state or community, through taxes for the investment made in the education of the individual.

7. College education costs.
   Find out the cost of a college education per student to the state. How much does the state lose when a college graduate moves out of the state? What factors may compensate for this?

8. Repayment of education costs and retirement.
   How much in taxes, social security or retirement deductions would a student need to pay during his productive life to repay the community and the state for its original investment and enable him to retire on a certain percent of his earnings for a specified number of years?

SUGGESTED VISUAL AIDS

Movie Films

Wastage of Human Resources, 10 min., color, EBF.

Cities: How They Grow, 11 min., color, EBF.

Cities: Why They Grow, 10 min., color, COR

Basic Elements of Production, 13 min., color, EBF.

Welfare--A History of United States Government Policies, 30 min., color, EBF.

Age of Specialization, 14 min., color, MH.

The Nature and Extent of the Population Explosion in the United States, 30 min., EBF.

Human Relations #5; Motivation and Production, 29 min., color, UTAH.

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

Director, Information Division
Public Health Service
U. S. Department of Health, Education, and Welfare
Washington, D. C. 20201

Director
Wyoming Department of Public Health
State Office Building
Cheyenne, Wyoming 82001

Superintendent of Public Instruction
Wyoming Department of Education
Capitol Building
Cheyenne, Wyoming 82001

Director
Wyoming Highway Patrol
Box 1708
Cheyenne, Wyoming 82001

Director
Wyoming Workman's Compensation Department
Box 408
Cheyenne, Wyoming 82001

CONSERVATION EDUCATION IMPROVEMENT PROJECT

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UNIVERSITY OF WYOMING
College of Education

ENVIRONMENTAL USAGE

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ENVIRONMENTAL USAGE

TEACHER'S DISCUSSION

Human societies can not exist in the world without changing their natural environment, i.e., clearing of forest land, plowing of grasslands, developing water irrigation systems, and developing lands for industrial and city complexes. These man made changes represent uses of the land, water, and air which alter or change the quality of the natural environment. We can not consider forest lands solely as sources for timber, grasslands solely as sources of forage, streams solely as sources of irrigation water or flat agricultural lands as cheap location sites for city and industrial units. Nevertheless, to live in and participate in a society which uses natural resources to produce rising levels of income and high standards of living, each of us, of necessity, exposes ourself to activities and to effects of variable environmental uses. Some of these effects are beneficial and others are so destructive that we must make every effort to prevent or reduce their detrimental influences. As a result, studies of uses of the environment are vital if societies are to survive.

Environmental Capability and Control

The first step in achieving better environmental use is to work towards the classification of variable environments. In such a process, the environment consists of the living and non-living components. The non-living components include the substrate (rocks and soil) and the medium (all water and the atmosphere). Living components include plants and animals. Each environment is different and has its own peculiar features, different capabilities to support specific segments of human society, and peculiar problems. Environmental use classification must take into account the total natural resources of the land, water, and air, as well as the human activities as factors influencing the potential capabilities of each environment. In other words, devising and using a system of environmental use classifications will permit not only the best use of the environment but will indicate what measures are necessary to maintain environmental quality on a long-term basis. A simplified example of the type of classification necessary for environmental capability is the land capability classification system used by the U. S. Soil Conservation Service. Table 1 is an abbreviated summary of that system.

Table 1. Land capability classification.

Class	Characteristics	Use	
		Primary	Secondary
1	Cultivatable, flat, well drained excellent soil	Cropland	Grazing Wildlife Recreation
2	Cultivatable, gently rolling, wet to droughty soils, contour and strip farming, good soils	Cropland Grazing	Wildife Recreation
3	Cultivatable with limitations, moderate slopes with only fair soil and drainage conditions	Cropland Grazing	Wildlife Urban Industrial Recreation
4	Cultivatable under only severe limitations of slope, and poor soil and drainage conditions	Grazing Urban Industrial Croplands	Wildlife Watershed Recreation
5	Not cultivatable, few problems for other uses	Grazing Forestry Watershed Urban Industrial	Wildlife Recreation
6	Not cultivatable, slight limitations from danger of erosion	Forestry Grazing Watershed Urban Industrial	Wildlife Recreation
7	Not cultivatable, moderate limitations from increased slope, fair soils, and harsh climate	Forestry Watershed Wildlife Grazing Recreation Urban	
8	Not cultivatable, steep slopes thin soils, severe climate	Watershed Wildlife Recreation	

ENVIRONMENTAL USAGE

Scientific, economic, and sociological information concerning natural environments and their characteristics is readily available. Environmental misuse can no longer be excused on the basis of ignorance. Why then do problems of environmental use exist today? Basically, our system of free enterprise is largely responsible for maintaining conflicts between public interest and private gain in the poorly integrated use of our resources. Successful resolution of these conflicts is the development of a better understanding of the consequences of poorly planned and executed uses of the environment.

Every unit of our worldly environments is under control of one or more international, national, state, local, or private interest. Consequently, it is important to clearly understand the concept of property. As such, property can not be considered as a material thing. Rather it is a bundle of rights which govern the activities involving the use of things. The nature of those property rights can change from time to time to reflect the whims of society. This concept applies to all types of property.

A major exercise of society's power to define the nature of property rights is zoning. Zoning is a form of police power or power of the State to safeguard the public interest in matters of environmental utilization. Environmental zoning regulations protect against misguided environmental uses. While zoning is an additional restriction on individual choice and freedom, it is a necessary evil related to the increasing numbers of human beings.

Use Demands

Expanding Human Populations

No place in the entire United States is better able to document the problems of environmental use in the face of an exploding human population than is California or the Megalopolis area between Washington, D. C. and Boston. Over 19 million people live in California. Between 1950 and 1960, 600,000 people or the equivalent of the population of San Diego were added annually to the already staggering state population. When a town of 50,000 develops every month or a village of 1,600 develops every day, environmental use problems are inevitable. Since 1900 space in California has decreased over 95 percent per capita.

Unfortunately, over half of California's population has settled in an area where arid or desert conditions prevail. Local water is scarce, and the water supply for the large urban areas of Southern California comes from major California river systems which are hundreds of miles away, as well as the Colorado River. Urban growth in the Southern California area would not have been possible without water. The water supplied to Southern California had to be taken from areas where development is now limited because all available water is alloted locally or claimed by Southern California. The question arises whether people should be allowed to continue settling in an arid region in defiance of natural arid conditions and expect to have water supplied to them at the expense of development or settlement in other regions.

Can humans expect to live in a desert and demand water supplies to grow lawns and trees on the same scale found in humid climates? At one time, Northern California residents were suggesting cession from the State because of Southern California's withdrawal of their water. One must realize that over 50 percent of the voters in California reside in the arid southern regions. In election issues or legislative matters related to water, they can usually be expected to control events in their favor. Is there, under such circumstances, reason to question whether majority rule should prevail at the expense of distant environments?

With the rapid population growth in many areas of the United States, little or no planning was put into new urban areas. A. E. Heller and S. E. Woods have graphically described these areas of new growth as "slurbs". In California, as in many other areas, this building expansion has followed the line of least resistance and has invaded those sites where building and development costs were the lowest. Generally, this has been on agricultural land where open, flat or gently rolling slopes favored quick, low-cost development. This urban expansion has reduced the agricultural output of California, particularly of the citrus and truck garden crops. Future citrus and vegetable crops produced in California will shrink to a level where they will be imported to meet the consumer demand. Some city planners go so far as to predict that reclamation of farmland now covered by cement and asphalt of the urban areas will be necessary. They envision the necessity of moving entire cities and urban areas to rocky, non-agricultural lands so as to provide more cropland in an attempt to feed the increasing human population.

In contrast to California, the Northeastern Seaboard of the United States contains over 38 million people in the area bounded by southern New Hampshire, northern Virginia, the Applachian foothills, and the Atlantic Ocean. As an area of nearly continuous urbanization, it has been called Megalopolis. Within a distance of 500 miles are located five cities with over a million people in each and over 12 cities with 200,000 to 800,000 in each. In comparison to the arid, open lands of the arid California region, the Megalopolis region is a mosaic of urban and rural environments that provide the special quality of that area. The Megalopolis city areas display a tall building core amidst the far flung urban sprawl.

The amount of water potentially available for use in Megalopolis is nearly double that of the arid West. Despite this, there are continued water shortages which are primarily related to polluted water and inadequate water storage facilities. Careless management of seemingly abundant water has permitted degeneration of the quality of the water. Intense concentrations of industry and steam generating power plants associated with industrial development are primary consumers and have also been primary polluters. Currently, progress is being made to improve the quality of the water as one means to maintain this type of human population concentration.

Different from Los Angeles, many water supply facilities in the Megalopolis area are dependent on interstate drainages. New York City is dependent on the headwaters of the Delaware River for its water supply. The drainage of that river involves not only New York but also Pennsylvania, New Jersey, and Delaware. As a result, the Federal Government and these four states have formed the Delaware River Basin Commission to promote equitable distribution of the waters of the Delaware River. As the various Megalopolis population centers continue their growth, competition for water continues. Such competition can not continue indefinitely nor can the population growth creating the increased water demand continue uncontrolled. Even in this abundantly blessed water area, there are limits to the amount of water available for human use and these inevitably will place a natural limit on the number of humans and the types of their activity which can be supported in Megalopolis. With this development, increased regulation or control of water supplies and coordinated distribution of water will be inevitable.

interstate drainages: river systems flowing through several states

As in Southern California, competition for agricultural land between the farm and urban development is intense. Eventually, the city is the winner, if for no other reason than that it costs too much in taxes to maintain farmland in urban developments. In some areas, property taxes represent 19-44 percent of the net income before those taxes are paid. Croplands can never pay as well as shopping centers or housing developments. Pressures for urban expansion are directed at the best farmland

and very little on pasture and woodland. Farmers can make considerable capital gain with the sale of their land to urban developers. It is not unusual to expect $10,000 per acre. Many of these farmers sell out good land and buy cheaper but poorer cropland for continued farming. This poor cropland can be made productive only at considerable investment of time and money which ultimately is passed on to the consumer in the city through higher food costs.

Efforts to correct or prevent this loss of valuable farmland usually have centered on the use of zoning laws. Depending on the state or local area, these zoning laws have been variable. Some have zoned agricultural lands according to soil types and prohibit their use for any urban development. At the same time, those lands are shielded from increased assessment valuations and service development costs associated with nearby urban developments, which would result in unbearable tax levies for farmland use. In effect, housing and urban developments are thus confined to the poorer land. Another approach is to zone agricultural land to prohibit any development in plots smaller than two acres. This latter method has not been as successful as the former. Some farmers oppose zoning because of its limitation on selling their property for a tidy profit. They do not consider the loss of their farmland as their problem and once again private gain is in conflict with public interest! Generally, the zoning of agricultural land is expanding and will serve to help protect croplands and provide green belts among a wilderness of cement and asphalt.

Developers, Urbanization and Industrialization

In the construction and location of cities and urban areas, natural features of the environment are all too often disregarded or never considered. At the very least, extensive property losses or unnecessary financial investments in protecting or maintaining personal property results. At the very worst, a major disaster may be fostered with much loss of human life.

New housing developments progress very rapidly and frequently subdivisions are constructed and sold in very short periods of time. In Fairfax County, Virginia, several such subdivisions were developed without the benefit of a community sewer system. Normally, this is no problem since septic tanks for each house are adequate under most circumstances. Unfortunately, these subdivisions were located on a heavy, water impervious soil, and the septic tanks could not drain and sewage treatment was impossible. New houses with all the conveniences of indoor plumbing had to dump their wash water on their lawns and resort to old-fashioned outhouses.

The same type of septic tank difficulty from a different cause arose in a new seaside resort subdivision in New Jersey. This subdivision was constructed on a land-filled wetland. Since the fill was very sandy, it would be expected to provide good drainage. However, the water table was only one foot beneath the surface of the ground, and not only inhibited an outflow of the septic tank effluent, but created a waterflow back into the septic tanks (Gottman, 1961).

water table: the level below which the ground is saturated with water

effluent: discharge or outflow

In Azusa, California, an entire subdivision was built on a tract of lowland adjacent to a small creek. A major road formed one boundary of the subdivision. Along the subdivision side of this road, early Azusa residents had constructed a cement wall nearly four feet high. Residents of the new subdivision paid little attention to the wall until one day a flash flood occurred above the town. The wall served a function to keep the water off of the road. With only the roofs of their new houses showing above the water, the residents were painfully reminded that they had built on a natural flood channel, well known to the natives of Azusa but unrecognized by the subdivision residents.

Subdivision developers do not stand alone in ignorance or disregard of the environment. In 1956, disastrous floods occurred in New England. Heavy damage was particularly concentrated on industrial developments. Floods of that magnitude were not common, but they had taken place often enough in the past that natives of the area had built only on high ground. However, during World War II, war-related industrial expansion saw many industrial complexes built on flood plain land in New England. Mainly, this choice of sites came about because that land was available at very low prices. In 1956, the disastrous floods did millions of dollars damage to these plants, and the taxpayers footed a large bill for disaster relief!

Urban and industrial construction on or along major faults are of major concern to many geologists. The now famous Alaskan earthquake of 1964 serves as a good example. The town of Anchorage suffered major damage to its downtown and Turnagain Arm areas. As early as 1959, residents of the city had been warned by geologists, in written reports, that the town was expanding on very unstable soil formations. It was located at the mouth of a river on water washed soil that formed an alluvial fan. This alluvial material rested on a water impervious clay known as Bootlegger Cove Clay. When wet, this clay served as a lubricated slide plane on which the alluvium was unable to remain stable. Along Turnagain Arm, geologists reported

faults: a break in the earth's surface which follows displacement along a plane of fracture

alluvial fan: a cone-shaped deposit of stream sediments dropped when the stream runs out onto a level plain that small landslides could be started merely by walking along the edge of the banks. It was on this material that the Turnagain Arm housing development was constructed. Major earthquake faults pass from the Aleutian Chain through the Anchorage area and down along the Alaskan coast. As in every area where these major faults exist, it is not a question of whether a serious earthquake will occur, but when will they take place! The Alaskan earthquake results are history. Property damage and loss of humans under the best conditions can be expected along earthquake faults. However, building on unstable land masses along these fault lines only unnecessarily increases the magnitude of the damage. Despite the information as to cause and effect of the earthquake's damage, promoters are again developing housing subdivisions on these same unstable areas.

In California, numerous housing developments have been built on and next to the San Andreas Fault, south of San Francisco. Real estate promoters in those areas never mention the fault's existence unless the buyer brings up the subject, which according to them is rare. Even then when those people are aware of the fault, they generally disregard its potential danger to them, even if their house straddles the fault line.

Large skyscrapers have been built in many California cities which are located along earthquake fault lines. Most notable is the Long Beach area. These buildings are supposedly earthquake proof, but they have never been put to the test in a severe quake. Recently, a delegation of Japanese engineers specializing in building design for earthquake areas in Japan refused to set foot in the tall buildings in Long Beach. As in the Alaskan earthquake, tall buildings may not collapse, but they can sway hard enough to act like a larger blender, crushing humans amongst moving furniture and falling fixtures. Losses which occur from this type of damage are so unnecessary and result primarily because of man's complete disregard for the natural environment.

Recent findings in the Denver, Colorado, area indicate man can aggravate an earthquake potential into becoming a serious threat. In March 1962, the Army's Rocky Mountain Arsenal drilled a deep well for the purpose of using it as a disposal site for poison wastes. The well cost $1.5 million. Within a month of the well's completion, earthquakes began and have continued ever since. The fluids pumped down the well lubricated the rocks below and promoted shifting of the earth's rock formations which caused the earthquake tremors affecting large sectors of metropolitan Denver (Evans, 1967).

With the rapid urban and industrial growth in many parts of the country, demands have increased for water, electric power, and flood control. Universally, the response to these demands in the West involves construction of so-called multi-purpose dams. These dams are considered multi-purpose because one or two uses usually can not justify the benefits in relation to the cost of the investment. Consequently, irrigation, culinary supplies, hydroelectric power, flood control, and recreation are the major uses considered. While there seems to be something of benefit for everyone in dam construction, this all too often is not the case. If dams are properly planned, located, and managed, they can be beneficial. Unfortunately, many dam constructions do not fit in this category.

In Wyoming, Anchor Dam on Owl Creek near Thermopolis was constructed by the Bureau of Reclamation on a porous limestone formation. To this day, after the expenditure of millions of dollars, the dam has yet to hold a drop of water. The new Yellowtail Dam is located on the same formation. Only time will tell whether it will be another Anchor Dam. Four proposed Bureau of Reclamation dam sites in the Jackson Hole area (Buffalo River, Gros Ventre River, Granite Creek in the Hoback drainage, and the Snake River Narrows) are to be located beneath sliding, unstable mountain slopes. One of these slopes, the Snake River Narrows, has a slide area two miles long.

porous limestone: limestone containing pores or other openings which may or may not interconnect. These openings may develop in presence of water, which dissolves away the limestone

The proposed Pot Hook Reservoir in the Savery-Pot Hook project is to be located on one of the most unstable land masses in Colorado. The extent of the land movement can be seen from the road between Savery and Steamboat Springs.

slide area: an area of earth or soil moving down a hill or mountain side

Despite the damage to the unique beauty and structure of the Grand Canyon, two dam sites are proposed on the Colorado River between Glen Canyon Dam on the Utah-Arizona border and Lake Meade. First, the water of the Colorado has been divided on the basis of an annual flow of 14.5 million acre feet when today the average annual flow is only about 11.5 million acre feet. In other words, the river flow is bankrupt having more water allocated than is present in the river. How then can water be obtained to fill two more dams? In addition, existing dam water impoundments lose tremendous amounts of water by evaporation and bank loss. Lake Meade and Lake Powell each lose 800,000 acre feet per year from evaporation when they are full. Using the market price of $50 an acre foot, this represents a financial loss of $6.7 million a year from the two dams. The loss of water by leakage into the canyon walls of Glen Canyon was originally estimated to reach 15 percent of the stored water. Actually, it is in excess of 30 percent per

acre feet: a volume of water equal to one surface acre of water one foot deep year. This is not to be unexpected since most of the canyon wall consists of porous sandstone.

Grand Canyon dam construction costs are justified on the basis of the payments expected to be received over a long-term period. Hydroelectricity is a major source of these payments. The electricity is sold on the open market. In the case of the two proposed dams, the market sale price would be 5.4 mills per kilowatt hour. It costs 5 mills to produce the hydroelectricity. Steam generated power plants can produce electric power for 4 mills, while nuclear power is now selling for 3.9 mills per kilowatt hour. By 1980, nuclear power is expected to sell for 2.1 mills per kilowatt hour. These two proposed dams are not feasible from any aspect, no matter how one considers them.

Hydroelectric power from big dams is not cheap power nor is it a money making proposition. Hydroelectric power operations have lost $51 million since 1963 in the Missouri River Basin Project; $50 million between 1957 and 1963 in the Bonneville Power Administration and the Trinity Project in California has been selling power at a loss of 3 mills per kilowatt hour (Evans, 1966).

As nuclear production increases, suitable nuclear waste disposal areas will become less available. To what extent vegetation, animals, and other elements of the environment will ultimately be affected by such placements has yet to be investigated thoroughly.

Present knowledge seems to indicate severe consequences to our environment if we fail to control atomic residues properly. Many future investigations will deal with proper and safe land use for radioactive disposal. When reactors are shutdown for fuel replacement or repairs, any component removed from the immediate area of the reactor core is radioactive, due to neutron bombardment. Such wastes may be wire, conduit, electric motors, rags, etc. The daughter fission products are tied to the irradiated fuel elements which must be removed to a site for separation and subsequent utilization or disposal. However, the major disposal problem is from the clean-up operations. Liquid wastes are usually stored in tanks at the reactor site. Research is under way to solidify these liquids into solids or fuse them, perhaps, into ceramics and glazes for placement in the storage area. Radioactive liquids might also be placed in selected geological formations deep beneath the rock layers of the earth's crust to assure non-re-entry into man's environment. Airborn wastes are usually of a local nature and do not constitute a hazard among the general population at this time.

residues: the remainder or rest of something

component: part of or piece of an object

daughter fission products: pairs of nuclei produced by a common fission process

ceramics: a coherent hard mass of which clay material is a prerequisite

To illustrate the magnitude of the disposal problem, between 1946 and 1960, 21,000 55-gallon drums and 360 large blocks of radioactive wastes were placed in the South Pacific, which was a total of 120,000 cubic feet of wastes. Between 1951 and 1959, 23,000 drums were placed into the Atlantic Ocean. Since then, of course, several more thousand containers have been added. It should be pointed out that the total volume of burial on the land is greater than that in the sea. This is because of the increased expense involved in placing the waste materials in the sea.

Superhighways

There were some 61 million automobiles registered in the United States in 1960. By 1964, Americans traveled 687 billion miles by car at a total cost of nearly $70 billion. To cope with this heavy car travel, Congress, in 1956, passed legislation calling for the creation of an Interstate Highway System which would take 16 years to complete at estimated cost of $41 billion (Brecher, 1965). Ninety percent of the cost was to be borne by the Federal Government, largely through increased use taxes. While the 41,000 miles of proposed Interstate construction will add only one percent to the total highway mileage, the impact on the landscape is much greater. Prior to 1956, highway rights-of-way in the United States accounted for some 15 million acres, or an area about the size of West Virginia. The Interstate program will add an additional one million acres. For two reasons, then, the impact on the land by new Interstate construction will be very serious. First, 75 percent of the construction will be using new land. Secondly, the new highway rights-of-way are about 10 times as wide as the old standard width of 33 feet (Wing, 1966).

Costs of Interstate construction are highly variable with respect to urban and rural sectors of the system. The average cost per mile of rural Interstate road is estimated at $625,000, while urban costs per mile are $3.7 million. In the centers of large cities, costs are even greater: 1.5 miles of Boston's Central Artery cost over $40 million per mile; and a crosstown section in Manhattan was estimated to have cost $100 million per mile. Besides the high costs of freeway construction, both in terms of land and finances, they are very inefficient transportation, especially in urban areas. In San Francisco, a two-track electric train system will be able to carry 30,000 persons in each direction at the peak rush hour periods. An eight land freeway can only accommodate 7,000 or 8,000 cars with some 10,000 or 12,000 persons. Both units cost approximately $13 million per mile to construct, but the land loss to the train system would be about one-third of that required by the freeway.

Other values and considerations are involved when considering where highways should be placed. Freeways proposed for Washington, D. C. in the early 1960's would have displaced 33,000 persons or 5 percent of that city's population from their homes. Only real property owners were compensated for their property losses. Until 1962, renters were not compensated for forced moving, and store owners were not paid for the value of their business itself. After 1962, moving expenses of $200 were allowed and up to $3,000 was paid to small business owners.

Because costs per mile in urban and rural areas are high, parks and public land areas are targets of Interstate highways because they are free and open. In Minneapolis, the Interstate System was scheduled to invade 15 Minneapolis park properties, while other state and county highways invaded 13 other park territories (Brecher, 1965). Almost a mile of the Yuba River was eliminated in the relocation of U. S. Route 40. In Montana, 78.4 miles of stream have been destroyed on 24 streams by highway and railroad construction. Interstate 40 will cut through Overton Park in Memphis, Tennessee. A second highway from Key West, Florida, through Everglades National Park has been proposed. Interstate 85 in Alabama threatens to cut through the National Wheeler Wildlife Refuge feeding and resting grounds which accommodates some 50,000 geese and 100,000 ducks. A temporary halt has restrained the invasion of U. S. 101 freeway through the California's Prairie Creek Redwoods State Park.

More familiar is the Colorado Red Buffalo Route controversy concerning routing of Interstate 70 over Buffalo Pass and through a part of the Gore Eagle's Nest Primitive Area.

Federal and Colorado highway officials favor this route over alternate routes despite the fact that costs of the Red Buffalo Route will be 3 or 4 times as expensive as using existing U. S. 6; the proposed Red Buffalo Route would pass through 9 or 28 dangerous avalanche areas on the east slope of the mountains; and despite being 10.6 miles shorter, the steeper grade of the Red Buffalo Route would take longer to travel than the existing longer U. S. 6 route. In addition, there is the invasion of the primitive area and the resulting changes associated with such an intrusion. Recently, a rancher aptly testified at a hearing on a proposed road in a Wyoming wilderness area to the effect that roads can be built, torn up, moved, and reconstructed anywhere. However, he had never known of anyone having been able to construct, rehabilitate or replace a mountain in a wilderness condition!

Other lesser problems can develop out of disregard for influences of plants and animals involved in highway location. In 1965, 6,052 whitetailed deer were killed on Michigan's highways with an estimated damage of $1.2 million to the vehicles (Wing, 1966). The relocation of Interstate 80 between Laramie and Walcott Junction increases the danger to motorists because historic migration routes of deer, elk, and antelope are cut by the new location which is not the case with the old U. S. 30 location. Interstate 90 between Gillette and Buffalo has a game crossing about every 10 miles. The welfare of the motorist, as well as that of the wildlife, have been entirely disregarded. Unless means can be found to safely move big game across these superhighways, human life will be endangered and the complete extermination of many big game populations is inevitable.

Wing (1966) clearly summarized the problem:

> No reasonable person is against a transportation system anymore than he is against bread and milk. Highways are vital. But at a time when the value of natural resources is increasing, because of scarcity, the question of where highways are to be put is just as vital as provision for the highways themselves.

The Columbus (Ohio) Citizen Journal editoralized concerning a proposed freeway:

> This freeway should be part of a broad community plan. It should include the saving of natural beauty as well as the building of a road.

Outdoor Recreation

With increasing population numbers, family income, amounts of leisure time, and increased mobility, outdoor recreation is threatening to convert parks, forests, and wilderness areas into recreational slums. Clawson (1963) has classified recreation areas into three major categories: (1) user-oriented areas; (2) intermediate areas; (3) resource-oriented areas. The user-oriented recreation areas are those areas characteristic of city parks where recreational use and activity are emphasized rather than the area's physical characteristics. A commonly used standard for this type of use is 10 acres per 1,000 people within a city. Currently, something like 4 acres per 1,000 people is the average condition.

Intermediate outdoor-recreation areas include those areas less than 100 miles distant from home. State parks and artificial reservoirs are typical sites. Depending on the site, emphasis will shift from general use and activity to special resource traits of the area. Water use is usually a part of the more heavily used intermediate areas. Others may be forested areas where the woodland attributes are emphasized. A desirable acreage for current use is thought to be about 30 acres of state parks for each 1,000 state population. However, where 10 million acres of state parks would be adequate now, by the year 2,000, it is estimated that to meet the demand, 50 million acres of state park land would be required. By 1960, 457 Federal reservoirs (managed by the Corps of Engineers, TVA, and Bureau of Reclamation) covering 6.9 million acres were intermediate areas.

Resource-oriented outdoor recreation areas are those regions where the major emphasis is on the natural qualities of the site. Included are 29 national parks, 83 national monuments, and 74 other National Park Service sites; 343 National wildlife refuges; 155 National Forests and numerous Bureau of Land Management lands.

The threats to open space and the resources that make outdoor recreation possible in all three categories are extensive and continuous. However, the most immediate destructive force is the outdoor recreationists themselves. Some states have found that their existing recreation facilities are overused by more than 30 percent (Dickinson, 1966). This is partly due to increased population growth and partly due to the number, size, and distribution of the recreation areas.

Unfortunately, with these overuse pressures far too many activities and uses of the intermediate and resource-oriented outdoor recreation areas are not based on the unique characteristics of those areas. As such, the recreationists artificially change the scenery and may adversely influence the environmental characteristics for which the areas were created.

The automobile is a major factor involved in these detrimental uses. Americans, through the use of the automobiles, have become extremely mobile and expect to have roads to allow them to go any place. Some people refer to this desire or condition as the Los Angeles syndrome in which 60 percent of an area is taken up by freeways and parking lots (Eichorn, 1966). The Angeles National Forest outside of San Bernadino, California, is an example of how a forest can become nothing more than a supervised parking lot and picnic area. Closer to home, the Canyon "supermarket" mall in Yellowstone National Park or the Colter Bay area in Grand Teton National Park characterize the problem. On the North Rim of Grand Canyon National Park, ponderosa pine trees over 300 years old were cut down to permit construction of a parking lot. All of these abuses can not be attributed to the automobile. In Everglades National Park, channels have been dredged for fishermen with a resultant change in the salinity of coastal and inland waters.

salinity: degree of salt concentration in the water

Four-wheel drive vehicles and dune buggies used by hunters, fishermen, and cross country tourists are causing serious erosion problems with their unregulated travel across federal forest and grazing lands.

Too many campgrounds in both intermediate and resource-oriented areas have enormous campground impact problems. Large numbers of campers seeking outdoor experiences exchange their crowded urban areas for equally crowded campgrounds. They compact the soil and trample the vegetation. They can not find the garbage cans; consequently, their kleenex, beer and soft drink cans, and other camping debris clutter the ground and pollute the streams. They listen constantly to loudly tuned portable radios or tape recorders with so much gusto that the noise subjugates or frightens away any animal life. They demand the development of such urban features as golf courses, dance halls, and even outdoor movie facilities. Even such seemingly harmless ventures as mountain climbing becomes serious creators of recreational slums. On Mt. McKinley, abandoned equipment and supplies litter the base camp sites where mountain climbing expeditions could afford to transport them in but were unable to carry them out. Also, outfitters and campers can pack full canned goods into wild areas, but somehow can't find the means to carry out the flattened empty containers.

The implication of all that has been said thus far was summarized by a Conservation Foundation statement made before the Senate Commerce Committee on July 27, 1966:

> Every modification of the physical environment brings about a series of changes, sometimes beneficial, sometimes adverse, often unforeseen. This does not mean that man should forego modifying the environment. It does mean, however, that we should make every reasonable effort to understand the results of our action, to minimize the detrimental impact of our actions upon the environment, and to take advantage of opportunities for positive benefits.

ENVIRONMENTAL USAGE

In the World, and particularly in North America, there is an urgent need for the protection of the public interest in the use of our environments. It is time now for us to assess our future uses of the environment and determine, while there is still time and space, the desirable kinds of environment and their uses with a feasible administration plan to accomplish our goals.

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ENVIRONMENTAL USAGE

RESOURCE UNIT

Time alloted ___________

Unit Objectives

1. To convey an awareness of the influence of man's activities in the use of his environment.

2. To develop an understanding of the relationship of proper environmental usage to man's well being and survival.

3. To develop an awareness of individual responsibility for promoting sound utilization of our environment.

Concepts

1. There are many different uses of the environment carried on by man with both detrimental and beneficial relations to man's welfare.

2. There is a scientific knowledge which permits recognizing most beneficial from detrimental types of environmental uses.

3. Each individual has a selfish interest and a responsibility for seeing that uses of the environment consider the public interest first in all cases as a matter of society's survival.

Activities

Discussion springboards for class debate

1. Zoning--good or bad
2. Dam construction--beneficial or detrimental
3. Hydroelectric power--a dilemma
4. Cars--with or without
5. National parks--protection or chaos

Projects

1. City and county zoning laws
2. Existing parks, open spaces, and green belts vs needs

SUGGESTED ORGANIZATIONAL DEVELOPMENT

Outline	Activities
I. Population growth and urban expansion	
A. Climatic influences	Activity: Zoning--good or bad
B. Agricultural modifications	
C. Factors of location and construction	Movie: The Green City
a. Soil influences	
b. Water and flood plain influences	
c. Earthquake influences	Movie: Alaskan earthquake
II. Economic Growth	
A. Multipurpose dams	Movie: Glen Canyon
a. Water storage and losses	
b. Power production	Activity: Dam construction--beneficial or detrimental
B. Interstate highway system	
a. Costs	
b. Effects	
III. Leisure time and outdoor recreation	
A. Types of outdoor recreation	
B. Natural conflicts arising from intensified recreational use	Movie: Let's Keep America Beautiful
	Activity: Existing parks and open spaces

SUGGESTED ACTIVITIES

Discussion Springboards for Class Debate

1. Zoning--good or bad
   a. We need better distribution of people, water, and open space; therefore, we must adopt zoning regulations to control where people live and how they use our resources.
   b. Zoning regulations are an infringement on individual freedom; consequently, such methods should be illegal.

2. Dam construction--beneficial or detrimental
   a. The Grand Canyon is unlike any other area on the face of the earth; therefore, we should protect it and should not allow any dams to be built in it.
   b. Power and water are essential to the welfare of the people of Arizona; therefore, the aesthetic values of the Grand Canyon are only minor considerations; the dam should be built.

3. Hydroelectric power--a dilemma
   a. As a natural by-product of dam construction, hydroelectricity can assist in repayment of the dam costs and therefore is one major justification for dam construction.
   b. Cheap nuclear power can now be readily produced, thus making hydroelectricity and dams out-of-date.

4. Cars--with or without
   a. The large number of automobiles owned by Americans require a high speed system of roads to provide transportation in urban and rural areas.
   b. Automobiles are inefficient means of transporting large numbers of people; therefore, other more efficient and less expensive means of transportation must be found.

5. National Parks--protection or chaos
   a. Visitor numbers are expected to be so great in parks like Yellowstone and Grand Teton National Parks that some restrictions will have to be placed on the number of visitors allowed within those parks at any one time in order to preserve the natural features of the area.
   b. National parks were created for people to visit and observe; therefore, no limitations should be made on the numbers who visit or stay over several days in those areas.

Projects

1. Determine if your town has any zoning laws and, if so, what type they are. Evaluate them to see if they are adequate, or, if none exist, what types should be adopted. Do the same for your county.

2. Tabulate all of the open spaces, parks, and green belts in your town. Are they adequate for the size of your community. Where, if any, are improvements needed?

SUGGESTED VISUAL AIDS

Movie films

* The Alaskan Earthquake, 20 min., color, USGS.

* Zero Hour in the Redwoods, 18 min., color, SC.

* No Time for Ugliness, 30 min., color, SMI.

Let's Keep America Beautiful, 14 min., color, KAB.

A City is Reborn, 25 min., color, S-USA.

Megalopolis--Cradle of the Future, 22 min., color, EBF.

The Pond and the City, 16! min., color, EBF.

The Green City, 27 min., color, SF.

Marshland is Not Wasteland, 14 min., color, RWP.

Our Changing Environment, 17! min., color, EBF.

Glen Canyon, 28 min., color, NAS.

Bulldozed America, 28 min., b & w, NAS.

The Myths and the Parallels, 27 min., b & w, NAS.

Cities of the Future, 30 min., color, MTP.

* Free films

FILM PUBLISHER KEY

ABP - Arthur Barr Productions
1029 North Allen Avenue
Pasadena, California 91100

AF - Association Films
347 Madison Avenue
New York, N. Y. 10000
Attn: Robert Bucher

AFPI - American Forest Products Industries
1835 K Street N. W.
Washington, D. C. 20006

AHP - Alfred Higgins Productions
9100 Sunset Boulevard
Los Angeles, California 90000

AMPI - American Petroleum Institute
Mrs. B. W. Cecil, Division of Marketing
1271 Avenue of the Americas
New York, N. Y. 10000

CF - Cathedral Films
1457 South Broadway
Denver, Colorado 80200

CFG - California Department of Fish and Game
926 J Street
Sacramento, California 95801

CON - Contemporary Films
1211 Polk Street
San Francisco, California 94109

COR - Coronet Productions
Sales Department
Coronet Building
Chicago, Illinois 60600

DEERE - John Deere and Company
Moline, Illinois 61265

Ealing Corp.- Ealing Film Loops
2225 Massachusetts Avenue
Cambridge, Massachusetts 02140

EBF - Encyclopedia Britanica
Rental and Purchase Libraries
1150 Wilmette Avenue
Wilmette, Illinois 60091

FAC - Film Associates of California
11014 Santa Monica Boulevard
Los Angeles, California 90025

IFB - International Film Bureau, Inc.
332 South Michigan Avenue
Chicago, Illinois 60604

KAB - Keep America Beautiful, Inc.
99 Park Avenue
New York, N. Y. 10000

KSC - Kaiser Steel Corp.
Kaiser Center
300 Lakeside Drive
Oakland, California 94600

MH - See McGraw-Hill Book Company

MHB - McGraw-Hill Book Company
Film Department
330 West 42nd Street
New York, N. Y. 10018

3M - 3M Company
Visual Products Division
Building 220-10 E
2501 Hudson Road
St. Paul, Minnesota 55119

MTP - Modern Talking Picture Service
1212 Avenue of the Americas
New York, N. Y. 10036

NAS - National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

NGF - Nature Guide Films
64 East Vende Road
Bountiful, Utah 84010

NYAP - New York State Air Pollution Control Board
84 Holland Avenue
Albany, New York 12208

PD - Pat Dowling Productions
1056 South Robertson Boulevard
Los Angeles, California 90000

RWP - Roy Wilcox Productions
Allen Hill
Meriden, Connecticut 06450

SC - Sierra Club
1050 Mills Tower
San Francisco, California 94104

SF - Stuart Finley
6926 Mansfield Road
Falls Church, Virginia 22040

SMI - Sterling Movies, Inc.
43 West 61st Street
New York, N. Y. 10023

S-USA - Sterling--USA
100 West Munroe Street
Chicago, Illinois 60600

Thorne - Thorne Films, Inc.
1229 University Avenue
Boulder, Colorado 80301

UC - University of California
Educational Film Sales
Los Angeles, California 90000

UPR - Union Pacific Railroad
Omaha, Nebraska 68100
Attn: Joe W. Jarvis, Supervisor of
Livestock and Agriculture

USDA - Visual Aids Service
Colorado State University
Fort Collins, Colorado 80521
(pay $1 postage and handling charge)

USGS - Information Office
U. S. Geological Office
Washington, D. C. 20242

USP - U. S. Public Health Service
Audiovisual Facility
Communicable Disease Center
Atlanta, Georgia 30333

UTAH - University of Utah
Audio Visual Center
Salt Lake City, Utah 84100

UWF - United World Films
1445 Park Avenue
New York, N. Y. 10000

WGF - Wyoming Game and Fish Commission
P. O. Box 1589
Cheyenne, Wyoming 82001

SOURCES OF FREE TEACHING MATERIAL

Director, Division of Information and Education
Forest Service
U. S. Department of Agriculture
Washington, D. C. 20250

Chief, Division of Information and Education
U. S. Forest Service, Region 2
Federal Center, Building 85
Denver, Colorado 80225

Chief, Division of Information and Education
U. S. Forest Service, Region 4
Forest Service Building
Ogden, Utah 84403

Chief, Division of Research and Education
Bureau of Outdoor Recreation
U. S. Department of Interior
Washington, D. C. 20240

Regional Director
U. S. Bureau of Outdoor Recreation
Federal Center
Denver, Colorado 80215

Information Officer
Geological Survey
U. S. Department of Interior
Washington, D. C. 20242

Chief, Division of Information
National Park Service
U. S. Department of Interior
Washington, D. C. 20240

Regional Director, Midwest
U. S. National Park Service
1709 Jackson Street
Omaha, Nebraska 68102

Chief, Division of Information and Education
Wyoming Game and Fish Commission
Box 1589
Cheyenne, Wyoming 82001

Director, Wyoming Recreation Commission
State Office Building
Cheyenne, Wyoming 82001

Keep America Beautiful, Inc.
99 Park Avenue
New York, New York 10016

Director of Information
The Izaak Walton League of America
1326 Waukegan Road
Glenview, Illinois 60005

Director of Education
National Audubon Society
1130 Fifth Avenue
New York, New York 10028

Chief, Conservation Education Division
National Wildlife Federation
1412 Sixteenth Street, N. W.
Washington, D. C. 20036

Director of Education
The Conservation Foundation
1250 Connecticut Avenue
Washington, D. C. 20036

Conservation Chairman
The Garden Club of America
598 Madison Avenue
New York, New York 10022

Sierra Club
1050 Mills Tower
San Francisco, California 94104

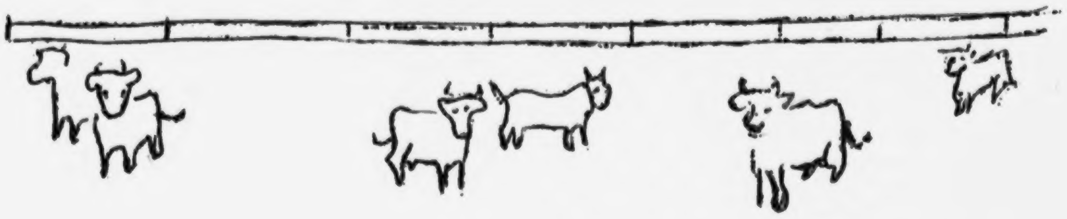
The Wilderness Society
729 Fifteenth Street, N. W.
Washington, D. C. 20005

APPENDIX C

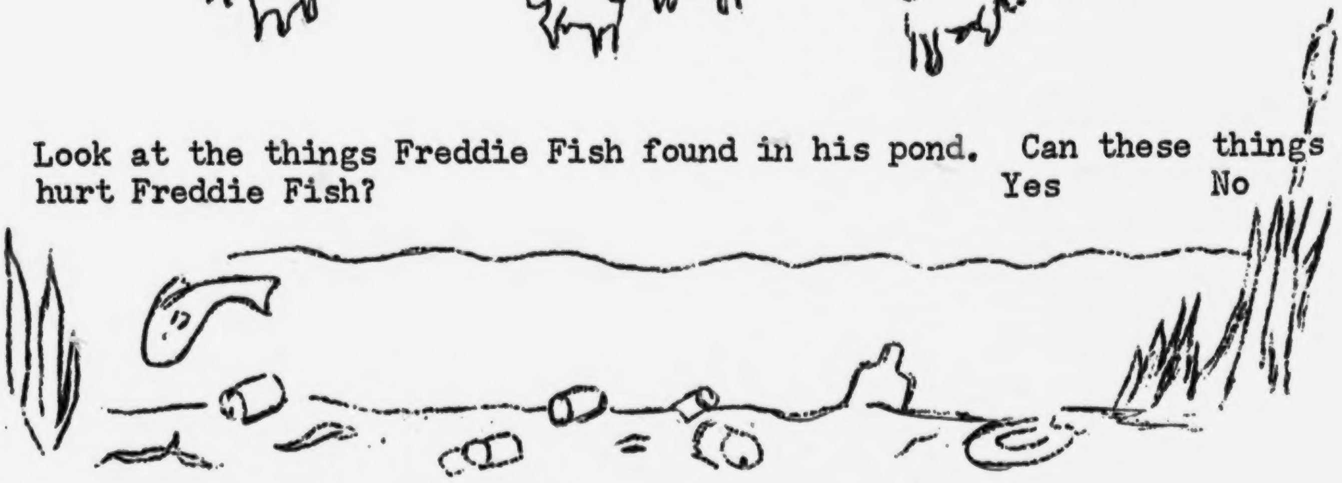
Pre and Post Unit Tests and Teacher Evaluation Form

PRETEST WILDLIFE UNIT
First Grade

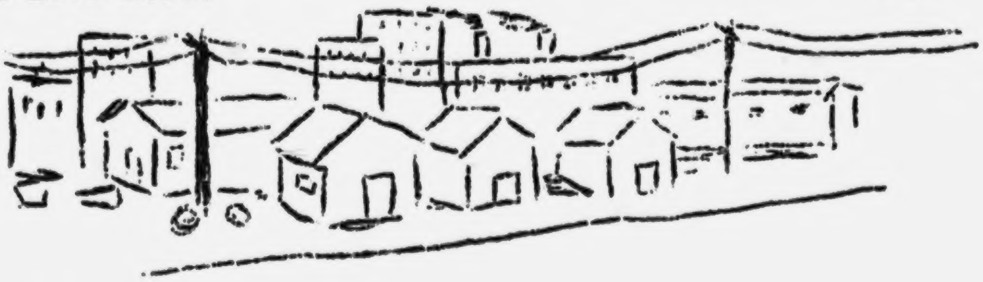
1. Can deer find enough to eat in this pasture? Yes No



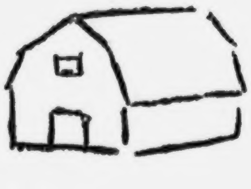
2. Look at the things Freddie Fish found in his pond. Can these things hurt Freddie Fish? Yes No



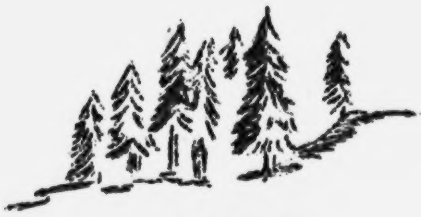
3. Deer and rabbits lived here before the city was built. Do they still live here? Yes No



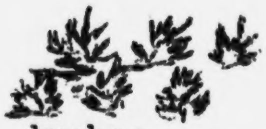
4. What does Danny deer need for shelter in the winter?



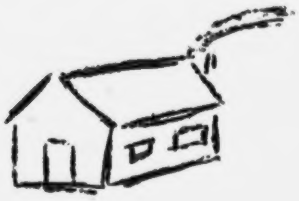
barn



trees

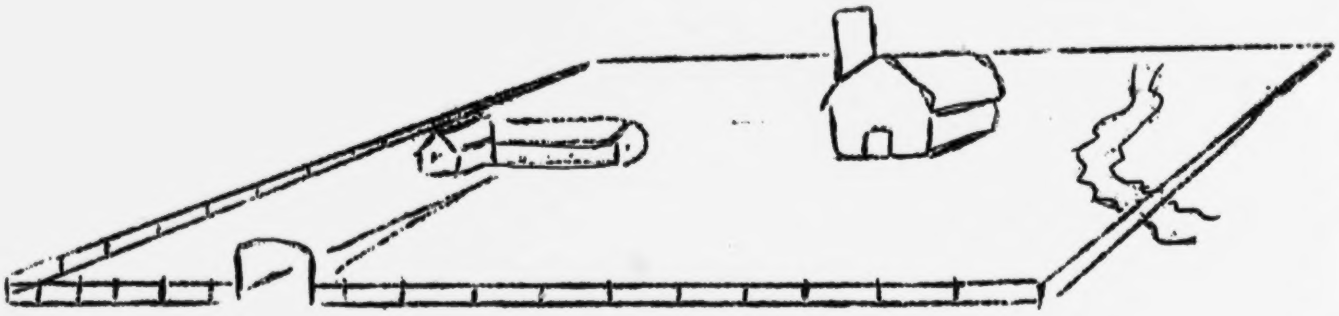


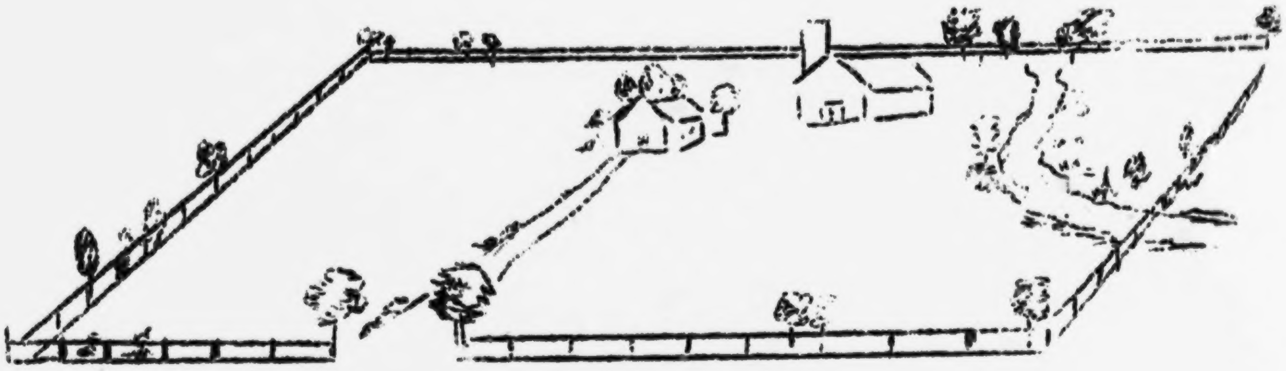
bushes



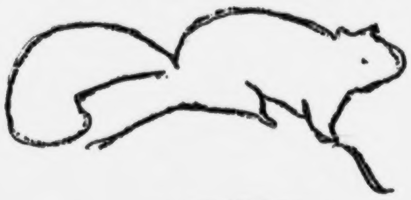
house

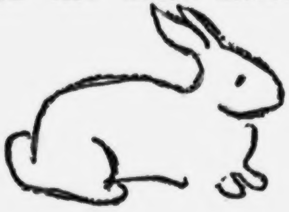
5. On which farm do you think you would find the most wildlife? Put an X on the farm that you think wild animals would like the best.

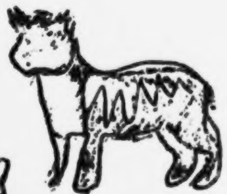


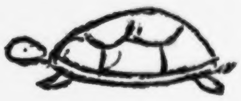


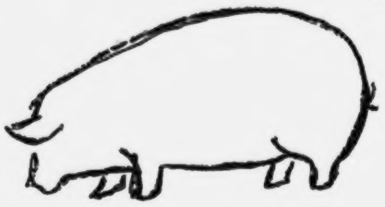
6. Draw a circle around the wild animals.

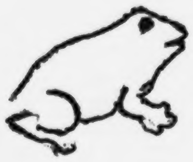


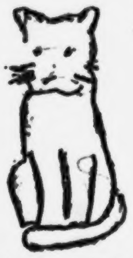


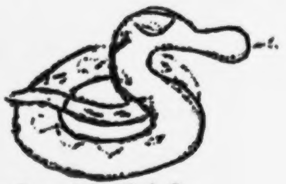




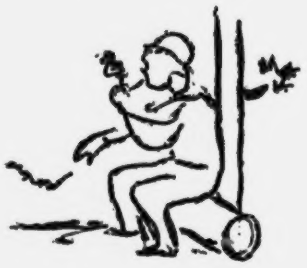


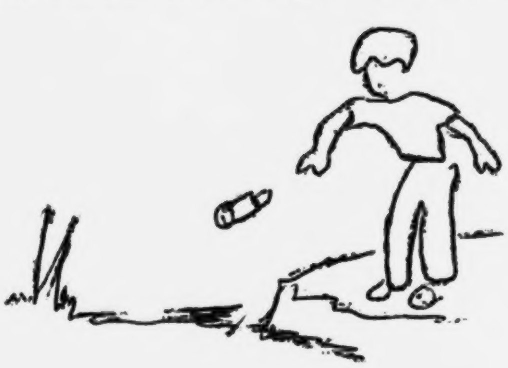


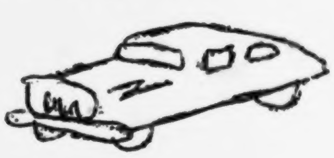


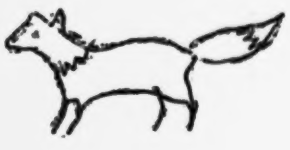


7. Put an X on the pictures that might be enemies of wildlife.









True and False

______ 8. We need to have laws to protect wild animals.

______ 9. It is a good thing that foxes kill some rabbits.

______10. If a stream is polluted* many animals may be harmed.

______11. Wild animals need some kind of shelter.

______12. Wild animals can eat anything.

______13. If we kill all the insects some kinds of birds may die because they have nothing to eat.

______14. Some animals depend on other animals.

______15. Some kind of cover is needed by animals.

______16. Children can help protect wildlife.

______17. Wild animals are useful to people.

______18. Some animals and birds may become extinct if people do not protect them.

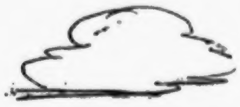
______19. Hungry deer may kill trees.

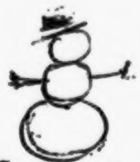
______20. Fish can live in a polluted stream.

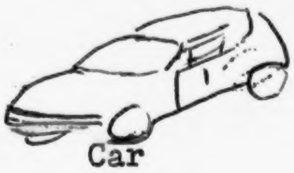
*Polluted, depend, and extinct are vocabulary words necessary to the unit.

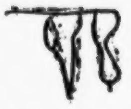
PRETEST WATER UNIT
Second Grade

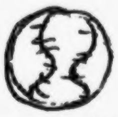
1. We may see water in many forms. Put a line under all the pictures that show forms of water. (Teacher should read aloud the word under each picture.)

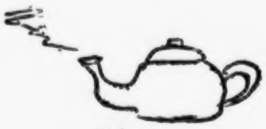

Cloud

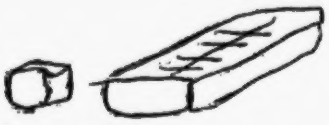

Snowman

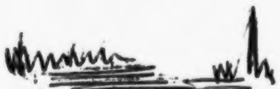

Car

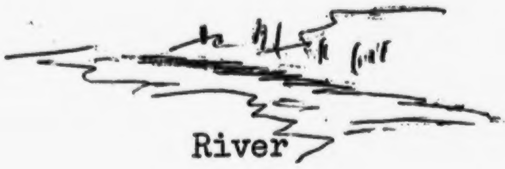

Icicles

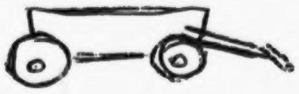

Baseball

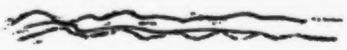

Steam

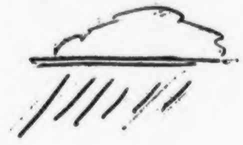

Ice cubes

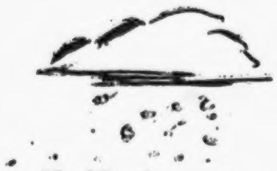

Pond


River


Wagon


Sea


Rain


Hailstones

Multiple Choice

______ 2. A swamp is (1) a kind of boat; (2) a large white bird; (3) a low, muddy place where water stands.

______ 3. A city may get water (1) from under the ground; (2) from a big building; (3) from plants they grow.

______ 4. When water evaporates (1) it shrinks; (2) it goes into the air; (3) it turns into ice.

______ 5. A water table can be found (1) in a well; (2) in the kitchen; (3) at the fire department.

______ 6. Fish cannot live in a stream (1) if plants grow in the stream; (2) if there is no air in the water; (3) if bears live near the stream.

______ 7. Rain can harm a farmer's field if (1) it washes the dirt away; (2) it soaks into the ground; (3) it rains in hot weather.

______ 8. Gullies are caused by (1) earthquakes; (2) volcanoes; (3) rain.

______ 9. Water erosion means (1) washing the soil away; (2) purifying the water; (3) putting water on crops.

______10. Water pollution means (1) building dams; (2) watering crops; (3) getting impurities in the water.

______11. One practice which helps to prevent water erosion is (1) planting grass on bare hillsides; (2) digging gullies; (3) building roads.

True and False

______12. All living things need water.

______13. Rivers are always clean.

______14. A river is a good place to throw trash.

______15. If water looks clean it is good to drink.

______16. Farmers can keep water from washing soil away.

______17. A polluted stream may harm many wild animals.

______18. Floods can harm the land.

______19. Dams can help prevent floods.

______20. Forest fires may cause floods.

PRETEST SOIL UNIT
Third Grade

1. If your mother sent you out to get some soil to put in a flower pot you would want to get very good soil. Put a check (✓) in front of the things you would want to find in the soil you put in the flower pot.

small rocks

sand

clay

water

small living animals

small living plants

salt

air

parts of dead animals

parts of dead plants

worms

glass

True and False

______ 2. Water can carry soil minerals to plants.

______ 3. Soils are all very much alike

______ 4. It takes a long time for good soil to form.

______ 5. Soils are better if there are small animals living in them.

______ 6. Plowing soil in a dry climate may cause soil to blow away.

______ 7. Soil helps to support plants.

______ 8. Rivers would be cleaner if there was less soil erosion.

______ 9. Different plants need different kinds of soil.

Multiple Choice

______10. If a farmer grows the same plants on his farm every year, the soil will (1) grow more plants; (2) wash away; (3) grow less plants.

______11. Sheet wash is (1) when rain washes away topsoil; (2) spraying crops; (3) irrigation of farm land.

______12. Soil may be protected from erosion by (1) building roads; (2) planting grass; (3) plowing.

______13. Farmers terrace hillsides because (1) it prevents soil erosion; (2) it makes the hills look better; (3) it keeps rabbits from eating young plants.

______14. To prevent soil erosion on a hill a farmer should (1) plow up and down the hill; (2) plow around the hill; (3) not plow the hill at all.

______15. Soil erosion may result when (1) too many houses are built; (2) too many trees are allowed to grow in the forest; (3) forest fires burn all the trees.

______16. Soils may be protected from wind erosion by (1) building dams; (2) planting trees; (3) putting sand in the soil.

______17. Gullies may be controlled by the use of (1) irrigation; (2) check dams; (3) rain.

______18. Soil erosion may be caused by (1) allowing too many animals to graze in a pasture; (2) contour plowing; (3) preventing forest fires.

______19. Soil can be improved through the use of (1) more water; (2) fertilizers; (3) insecticides.

______20. To prevent soil erosion after a forest fire (1) more trees should be planted; (2) dams should be built; (3) the land should be cleaned off.

Pretest - GRASSLANDS

Name____________________________
Last First

True and False

______ 1. Antelope that live on the grasslands would be better off if there were no predators of any kind.

______ 2. Overgrazing may lead to soil erosion.

______ 3. Lakes and reservoirs may fill up with silt when grass is removed from the surrounding country.

______ 4. All trees and bushes should be cut in grasslands so that more grass can grow.

______ 5. Crop rotation can make the soil better.

______ 6. Grasses help build up the soil.

______ 7. Grasses should be removed to prevent prairie fires.

______ 8. Grasses are useful to man as a food crop.

______ 9. Most deer eat grass.

______10. Grasses help to prevent floods.

______11. Dust storms may be a serious problem if grasslands are plowed.

______12. Many burrowing animals live in the grassland.

______13. Many grazing animals eat mostly bushes and small trees.

Multiple Choice

______14. Forests would replace grasslands if (1) the soil were better; (2) there were more moisture; (3) seeds of trees could reach grasslands; (4) there was less moisture.

______15. Predators that live in grasslands are (1) prairie dogs; (2) tigers; (3) buffalo; (4) wolves.

______16. Many birds that live in the grasslands build their nests (1) in trees; (2) on housetops; (3) on the ground; (4) in prairie dog holes.

______17. When man plows up grasslands to plant crops (1) the soil gets better; (2) the soil holds more moisture; (3) the soil is exposed to wind erosion; (3) more soil is formed.

______18. Soil holds more moisture (1) when it has been plowed; (2) when it is covered with grass; (3) when there are no plants to use the moisture.

______19. Strip cropping is usually done (1) to give the soil a rest; (2) to enrich the soil; (3) to increase moisture in the soil; (4) to prevent fires.

______20. Large animals that live on the grasslands are usually able to (1) fight very well; (2) run very fast; (3) hide in the trees.

Pretest - FORESTS

Name______________________________
Last First

True and False

______ 1. Dams and reservoirs are kept cleaner when trees are removed from a watershed.

______ 2. When forests are burned or are cut down they can always be replanted.

______ 3. Forests can grow in any kind of soil if there is enough moisture.

______ 4. Forests help to prevent floods.

______ 5. Forests help to prevent soil erosion.

______ 6. Too many deer may harm a forest.

______ 7. Forests take too much water from the ground and cause the water table to fall.

______ 8. People should be allowed to hunt in the forests.

______ 9. More water will remain in the soil if there are trees growing in it.

______10. Forest fires may cause floods.

______11. Forests are sometimes raised as a crop.

Multiple Choice
(Choose the best answer)

______12. An animal that damages trees is the (1) bear; (2) porcupine; (3) raccoon; (4) squirrel.

______13. An important use of forests is (1) for recreation; (2) to prevent fires; (3) to grow grain crops; (4) to save land for future cities.

______14. A forest product is (1) cereal; (2) paper; (3) cloth; (4) ink.

______15. Good forest management would (1) never allow any trees to be cut; (2) would allow people to cut all the trees they needed; (3) provide for some cutting and some replanting; (4) plant larger forests.

______16. When trees are removed from a watershed the streams (1) carry less water; (2) carry less soil; (3) carry more soil; (4) are cleaner.

______17. To replace most forests that are destroyed it takes (1) one year; (2) ten years; (3) thirty years; (4) more than fifty years.

Name ______________________
Last First

_____18. Some enemies of trees are (1) birds; (2) bats; (3) insects; (4) bears.

_____19. Forests should be used to (1) protect wildlife; (2) provide recreation for our people; (3) preserve beauty; (4) do all of these things.

_____20. Overgrazing of domestic animals in forest areas can (1) improve the soil; (2) cause erosion and floods; (3) cause forest fires; (4)prevent floods.

Pretest - MINERALS AND OIL

Name______________________________
Last First

True and False

______ 1. Oil is heavier than water

______ 2. Some countries have mineral shortages but the United States has a plentiful supply.

______ 3. Synthetics can be used to replace some minerals.

______ 4. Some minerals can be reused.

______ 5. Oil is a source of power.

______ 6. We recover large amounts of oil from oil shale.

______ 7. Alloys are impurities that must be removed from metals.

______ 8. Oil is highly reuseable.

______ 9. Uranium is used to produce power.

______10. Copper is very important in many industries.

Underline some good solutions to the shortage of minerals

11. discover new deposits
12. reuse more minerals
13. increase market value
14. employ more miners
15. substitute alloys
16. dig deeper mines
17. substitute synthetics
18. use low grade ores

Underline consumers of minerals

19. manufacture of chemicals
20. power production
21. agriculture
22. industry
23. transportation
24. communication

Multiple Choice

______25. An ore is a substance (1) containing iron; (2) containing enough of a mineral to mine profitably; (3) containing a valuable metal; (4) containing gold, silver or copper.

Name ______________________
Last First

______26. There is much oil remaining if (1) we could find it; (2) we could extract it economically; (3) we could find ways to transport it where it is needed; (4) we could purify it.

______27. The most common metallic element found on the earth's surface is (1) iron; (2) nickel; (3) aluminum; (4) copper.

______28. A synthetic which has been substituted for some minerals is (1) rubber; (2) aluminum; (3) teflon; (4) limonite.

______29. Iron is (1) not reusable; (2) highly reusable; (3) slightly reusable; (4) thrown away once it is used.

______30. Lead (1) has a harmful effect on man; (2) is a very light metal; (3) is used to construct rockets; (4) rusts easily.

Pretest - POLLUTION

Name ______________________________
Last First

______ 1. Twenty parts per million of sulfur dioxide in the air is harmless to people.

______ 2. Secondary pollutants are less harmful in the air than primary pollutants.

______ 3. Harmful air pollutants are often invisible.

______ 4. Long-lasting insecticides that will protect areas against insects for many years should be used.

______ 5. The daily use of water in the United States is greater than the supply available.

______ 6. Anaerobic bacteria live only where there is a supply of oxygen.

______ 7. Most of the smog problem is caused by coal-burning industries.

______ 8. Ozone is a more powerful oxidizer than oxygen.

______ 9. Sewage treatment plants remove all organic wastes before returning water to a stream.

______10. Many cities in the United States must use water that has come through another city's sewer system.

______11. The Food and Drug Administration inspects most of the food we eat.

______12. Radioactive wastes are safe to empty into streams because the water dilutes them.

______13. Some of the pesticides used become more poisonous after they have been in the soil for some time.

______14. Aldrin and heptachlor are good insecticides to use because they evaporate quickly.

______15. Chemical companies sometimes recommend that more pounds of insecticides per acre be used than is really necessary.

______16. The more insecticide a farmer uses to protect his plants, the better his crop will be.

______17. Water systems remove chemical poisons from the water before it comes to our homes.

______18. Humans get residues of pesticides on the food they eat and in the water they drink.

______19. Most insecticides, pesticides and weed killers are harmful to humans.

Name ______________________
Last First

______20. Litter may indirectly cause disease.

______21. Food plants grown near the road may carry poisons deposited by automobiles.

______22. Many industries discharge their waste products directly into our rivers.

______23. One person can do nothing to solve the tremendous problem that litter creates.

______24. Sewage plants treat water to kill viruses before returning the water to a stream.

Multiple Choice

______25. Each year littering costs taxpayers in the United States (1) $10,000; (2) $100,000; (3) $1,000,000; (4) $1,000,000,000.

______26. Fires starting in rubbish or litter destroy a home in the United States every (1) 12 minutes; (2) 12 hours; (3) 12 days; (4) 12 weeks.

______27. A good insecticide should (1) be very poisonous; (2) kill all kinds of insects and spiders; (3) stay in the fields for many years; (4) last only a short time.

______28. The pesticides used most widely (1) disappear from the soil in only a few months; (2) evaporate into the atmosphere; (3) build up more and more poison in the soil each year; (4) become harmless after a short time.

______29. Two pesticides, aldrin and heptachlor (1) become more poisonous in the soil; (2) become less poisonous in the soil; (3) are harmless in the soil; (4) evaporate quickly.

______30. Pesticides washed into streams (1) are diluted so they are harmless; (2) may be concentrated by water plants or animals; (3) settle to the bottom; (4) are neutralized by water.

______31. Plants grown in soil that has an accumulation of some pesticides (1) take up some of the poisons; (2) are more nutritious; (3) do not take up any of the poisons; (4) have a bad taste.

______32. The half-life of a radioactive element refers to (1)the time it takes for half of its radioactivity to disappear; (2) the length of time that half of the people exposed to the element would live; (3) the length of time it would take for half of the weight of an element to go away; (4) the kind of element involved.

Name ______________________
Last First

______33. Secondary pollutants result when (1) too many people burn trash; (2) a temperature inversion occurs; (3) too many industries burn coal; (4) primary pollutants combine.

______34. One of the most dangerous gases released into the air by automobiles is (1) sulfur fumes; (2) carbon monoxide; (3) carbon dioxide; (4) ozone.

______35. Litter may be dangerous to us because (1) it is ugly; (2) it creates breeding grounds for rats and insects; (3) it costs us money; (4) it is unfair to foresters to have to clean it up.

Pretest - HUMAN RESOURCES

Name ______________________
Last First

Check the statement in each group that you believe to be most true.

1. A. There are more families living on farms than are able to make a decent living.
   B. There should be more people living on farms.
   C. We have about the right amount of families living on farms.

2. A. Government money is being wasted in trying to educate people to get better jobs.
   B. Government money that is being spent to educate people is a good investment.
   C. The government should stay out of education.

3. A. In a democracy an individual who is not educated only harms himself.
   B. In a democracy an uneducated person is apt to be a liability to society.
   C. Education has very little to do with a person's value to society.

4. A. Money spent on education can be considered an investment if it increases the long-term productivity of the individual.
   B. Money spent on education can not be considered an investment.
   C. Money spent on education can be considered an investment only when a return on the investment can be seen in a few years.

True and False

______ 5. The future expected output of the artistic, scientific and judicial minds can be accurately estimated.

______ 6. Education increases a sense of responsibility toward good government.

______ 7. Lack of education leads to poverty, unemployment and stifling of the intellect.

______ 8. Dropouts are concentrated in occupations having low incomes and high unemployment.

______ 9. A person who has had a suspended sentence, been on parole or probation is not likely to be arrested again.

______10. Crime increase is not due to more criminals but to more crimes committed by the same people.

______11. Education has very little to do with the amount of money a person may expect to earn.

______12. Investment in the Highway Patrol could be expected to reduce highway accident costs.

______13. Low income groups are increasing in the cities.

Name ______________________
Last First

______14. People who are out of work are usually just too lazy to work.

______15. Every year 1 out of 5 people in the United States move to a new location.

______16. A high school graduate has a better chance to earn more money in his lifetime than a high school dropout.

______17. The only value that should be considered in human resources is the monetary value.

______18. The most rapid population growth in the United States is taking place on the East Coast.

______19. The Negro population in the South is increasing rapidly.

Multiple Choice

______20. The region of most rapid population growth in the U. S. is (1) East Coast; (2) Gulf Coast; (3) West Coast; (4) Great Plains.

______21. Persons living on farms in the United States number approximately (1) 12,000; (2) 12,000,000; (3) 120,000; (4) 120,000,000.

______22. To improve national educational levels public schools in the United States spend each year (1) $25.8 billion; (2) $25.8 million; (3) $10.2 billion; (4) $5.3 billion.

______23. Education statistics indicate that in 1965 the number of people 18 and over in the U. S. with less than an elementary education was close to (1) 2 million; (2) 20 million; (3) 200 million; (4) 5 million.

______24. The average life expectancy in 1965 was (1) 65 years; (2) 70 years; (3) 80 years; (4) 60 years.

______25. The leading cause of death in the United States is (1) cancer; (2) tuberculosis; (3) pneumonia; (4) heart disease.

______26. The population in the United States in 1968 will be closest to (1) 200 million; (2) 150 million; (3) 100 million; (4) 250 million.

______27. The average age of the population is (1) increasing; (2) decreasing; (3) staying about the same.

______28. According to the F.B.I. serious crime is (1) increasing; (2) decreasing; (3) staying about the same.

______29. The Job Corps is a government program that (1) finds jobs for people; (2) supports people who have lost their jobs; (3) trains unskilled and poorly educated people so they can find jobs.

Name ______________________
Last First

______30. Unemployment is most likely to come to people with (1) college education; (2) high school education; (3) elementary school education; (4) less than elementary school education.

______31. The people who are most apt to move and move farther from their original location are (1) highly educated people; (2) people with only high school education; (3) high school dropouts; (4) people with less than an elementary education.

______32. The number of young people involved in police arrest is (1) more than 20 percent; (2) 15 percent; (3) 10 percent; (4) less than 5 percent.

______33. Today well-to-do people are moving (1) from small towns to cities; (2) from farms to cities; (3) from cities to suburbs; (4) from cities to the farm.

Pretest - ENVIRONMENTAL USAGE

Name ______________________________
Last First

True and False

______ 1. Over half of California's population has settled in an area where arid or desert conditions prevail.

______ 2. Water must be brought hundreds of miles to supply the population of southern California.

______ 3. If the majority of people in California vote on water allocation, the majority would be certain to be right.

______ 4. Urban areas have nearly always been carefully planned.

______ 5. The easiest area available for urban expansion is often good farmland.

______ 6. High property taxes often force farmers to sell land for city development.

______ 7. Some city planners predict that reclamation of farmland now covered by cement and asphalt of urban areas may eventually be necessary.

______ 8. Private gain is often in conflict with public interest.

______ 9. In construction and location of cities and urban areas natural features of the environment are often disregarded.

______10. Skyscrapers built along fault lines in California are perfectly safe because the engineers made them earthquake proof.

______11. Human societies need to change the natural environment in order to exist in this world.

______12. New York gets most of its water from the Hudson River.

______13. Zoning laws could be used to protect productive farmland from unreasonable taxation.

______14. Anchor Dam in Wyoming stores water for irrigation.

______15. Building dams may sometimes cause water to be lost from a river system.

______16. It is dangerous to build cities on fault lines.

______17. Much of the damage and loss of life that occurred in the last Alaskan earthquake could have been avoided.

______18. If you should plan to buy a house in an area subject to earthquakes, you should ask a real estate agent about the safest location.

______19. Highways and roads are built only on unproductive land.

______20. America needs more and better highways for more efficient transportation.

Name ______________________
Last First

_____ 1. The climate in southern California is (a) hot and wet, (b) hot and dry, (c) cold and wet, (d) cold and dry.

_____ 2. The chief water problem of the Northeastern Seaboard is (a) too much water, (b) not enough water, (c) polluted water, (d) salt water.

_____ 3. The primary consumer of the water of the Northeastern Seaboard is (a) laundries, (b) drinking water, (c) people who water their lawns, (d) industry.

_____ 4. New York City is dependent for its water supply on the headwaters of the (a) St. Lawrence River, (b) Delaware River, (c) Hudson River, (d) Mississippi River.

_____ 5. On the Northeastern Seaboard farmers are apt to sell their land because (a) the soil is too poor for farming, (b) property taxes are too high, (c) crops do not grow too well there, (d) the land is too mountainous.

_____ 6. Farmland in urban areas could be protected by (a) using it for shopping centers, (b) being bought by the state, (c) passing zoning laws, (d) developing it for homesites.

_____ 7. Anchor Dam on Owl Creek in Wyoming is located on (a) sandstone, (b) basalt, (c) limestone, (d) granite.

_____ 8. Land classified by the description "not cultivatable, steep slopes, thin soils, severe climate" could be used for (a) watershed, (b) urban areas, (c) cropland, (d) grazing.

_____ 9. Land classified by the description "cultivatable, flat, well drained, excellent soil" should be used primarily for (a) grazing, (b) urban development, (c) forestry, (d) cropland.

_____ 10. Most of California's population settled in an area of (a) heavy rainfall, (b) desert conditions, (c) moderate climate, (d) forest land.

_____ 11. Most cities in the United States have (a) been carefully planned, (b) been zoned to protect farmlands, (c) grown without planning, (d) prohibited building on dangerous sites.

_____ 12. When a city is growing and looking for new areas of land to use for city development, it will most frequently choose (a) rocky, unproductive land, (b) forest land, (c) hills, (d) good farmland.

_____ 13. A good formation on which to build a dam would be (a) limestone, (b) sandstone, (c) marble, (d) granite.

_____ 14. A strata which may cause slides when wet is (a) sand, (b) clay, (c) limestone, (d) gravel.

_____ 15. If you were in a skyscraper during an earthquake, you would feel it most (a) on the ground floor, (b) on the 5th floor, (c) on the 10th floor, (d) on the 15th floor.

Name ______________________
Last First

______16. The most immediate destructive force in recreation areas is (a) earthquakes, (b) the recreationist, (c) highways, (d) golf courses and supermarkets.

Completion

After each land description indicate the best primary land uses. (Use only the letters. Use as many letters as you think necessary for each answer.)

Land Uses

A. Cropland
B. Grazing
C. Watershed
D. Urban
E. Industrial
F. Forestry
G. Wildlife
H. Recreation

1. Cultivatable, flat, well-drained, excellent soil

____

2. Not cultivatable, slight limitations from danger of erosion

____

3. Cultivatable only under severe limitations of slope, and poor soil and drainage conditions

____

4. Cultivatable, gently rolling, wet to droughty soils , contour and strip farming, good soils

____

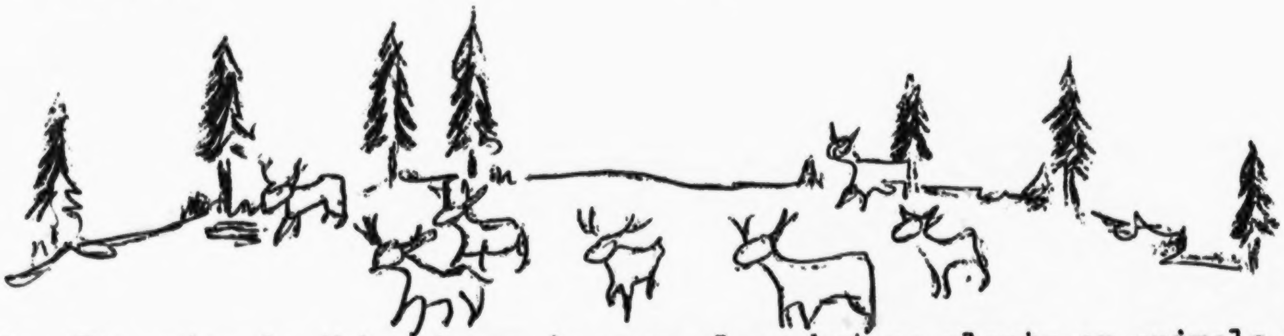
5. Not cultivatable, steep slopes, thin soils, severe climate

____

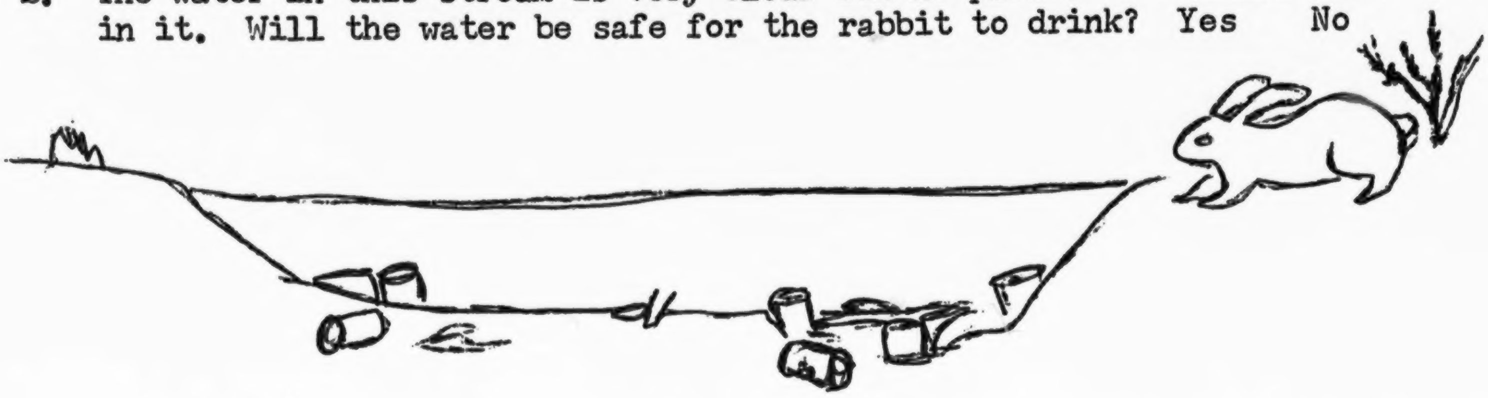
Post test - WILDLIFE

Name ______________________________
Last First

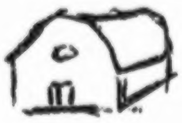
1. Would it be a good thing if there were this many deer all over the forest? Yes No



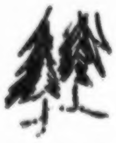
2. The water in this stream is very clear but no plants or animals live in it. Will the water be safe for the rabbit to drink? Yes No



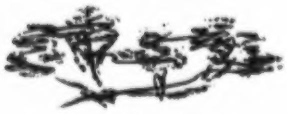
3. This rabbit is frightened. He has just seen a hawk. Where would the rabbit go to hide?



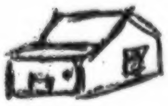
barn



trees

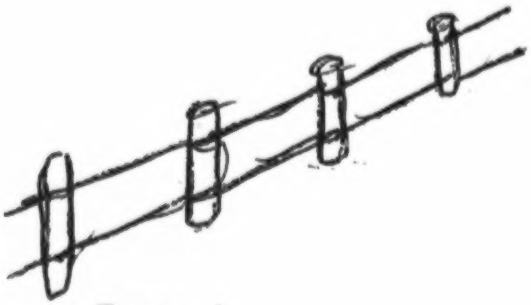


bushes

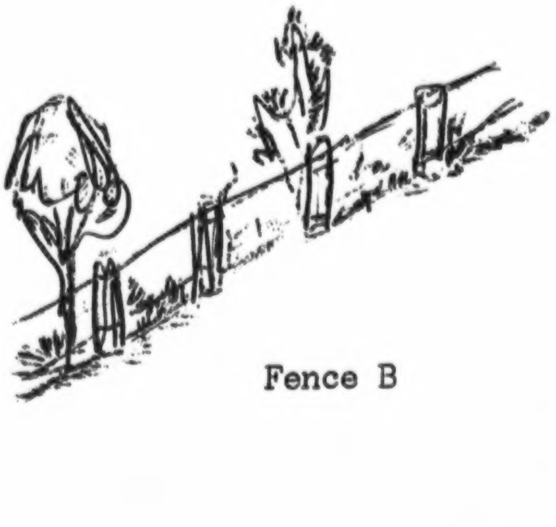


house

4. Here are pictures of two fences. Fence A is kept clean. Fence B has weeds and bushes growing beside it. Which fence would help the wildlife on the farm? Put an X on the fence that would be best for wildlife.



Fence A

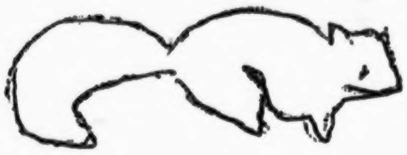


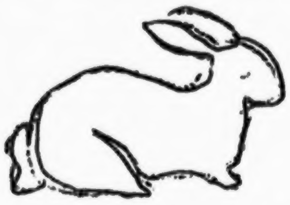
Fence B

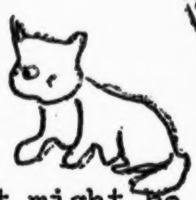
Post test - WILDLIFE

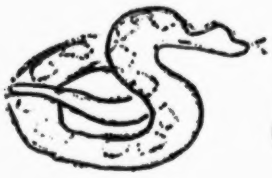
Name ______________________________
Last First

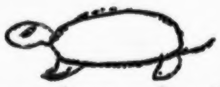
5. Draw a circle around the wild animals.

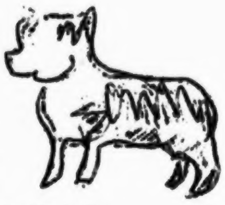




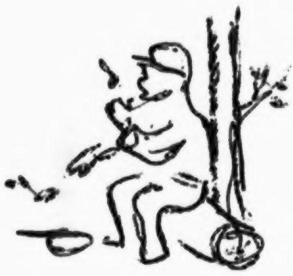


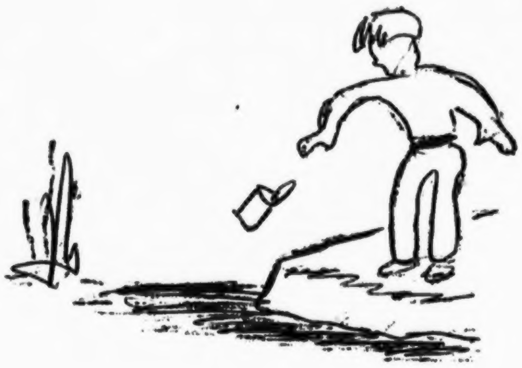


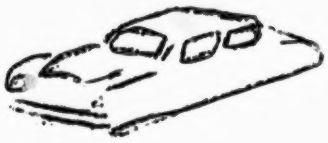


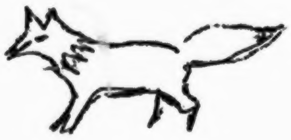


6. Put an X on the pictures that might be enemies of wildlife.









True and False

______ 7. When we poison insects we may also poison birds.

______ 8. We should kill mountain lions that eat deer.

______ 9. Laws are needed to help protect wildlife.

______10. Wild animals need cover for protection from their enemies.

______11. If a stream is polluted fish cannot live in it.

______12. Animals can drink from a polluted stream.

______13. Wild animals are useful to people.

______14. Wild animals must have some kind of shelter.

______15. Some animals must eat other animals in order to live.

______16. Wild animals can eat anything.

______17. Deer can kill trees.

______18. Some animals and birds may become extinct if people do not protect them.

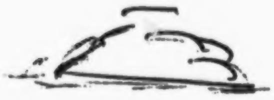
______19. Everyone should help to protect wildlife.

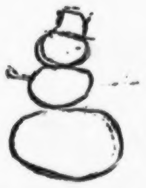
______20. When cities were built many wild animals lost their homes.

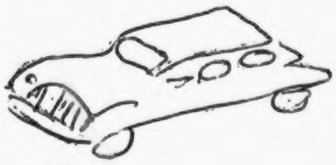
POST TEST WATER UNIT

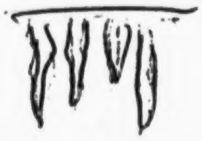
Name ______________________
Last First

1. We may see water in many forms. Put a line under all the pictures that show forms of water. (Teacher should read aloud the word under each picture.)


Cloud


Snowman


Car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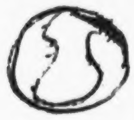
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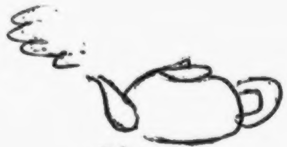
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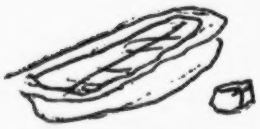
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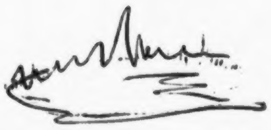
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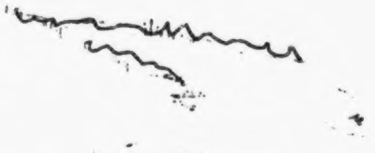
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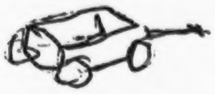
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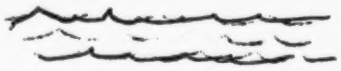
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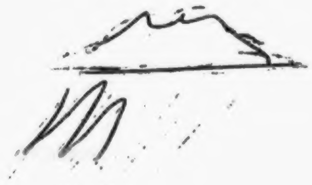
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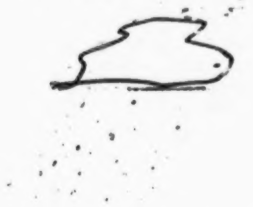
Hailstones

True and False

______ 2. Forest fires may cause floods.

______ 3. Overgrazing may cause floods.

______ 4. All living things need water.

______ 5. Rivers are a good place to throw trash.

Post test - WATER Name ______________________
Last first

______ 6. A polluted stream may harm many wild animals.

______ 7. Dams help prevent floods.

______ 8. If water looks clean, it is good to drink.

______ 9. Rivers are always clean.

______10. Farmers can keep water from washing soil away.

Multiple Choice

______11. A swamp is a good place for (1) water birds; (2) prairie dogs; (3) rattlesnakes.

______12. Water pollution means (1) irrigating crops; (2) getting impurities in the water; (3) preventing erosion.

______13. A city may get its water from (1) plants they grow; (2) a lake; (3) a big building.

______14. A water table would usually be found (1) underground; (2) in the kitchen; (3) in a store.

______15. When water evaporates (1) it gets smaller; (2) it turns into ice; (3) it goes into the air.

______16. Water erosion means (1) purifying water; (2) contour plowing; (3) washing the soil away.

______17. If a stream is polluted it (1) has many fish in it; (2) has no fish in it; (3) has good drinking water.

______18. Gullies are caused by (1) erosion; (2) earthquakes; (3) volcanoes.

______19. Water erosion may be prevented by (1) planting grass on bare hillsides; (2) plowing downhill; (3) burning off grass.

______20. Rain can harm crops if it (1) washes soil away; (2) rains in hot weather; (3) soaks into the ground.

Post test - SOIL

Name [redacted] ______________________________
Last First

1. Put a check in front of the materials you would expect to find in good soil.

small rocks
air
sand
parts of dead animals

small living plants
salt
parts of dead plants
large rocks

small living animals
water
clay
worms

True and False

______ 2. Soils are very much alike.

______ 3. Plants need soil to give them support.

______ 4. Plants can grow without soil if they have plenty of pure water.

______ 5. Plowing soil in a dry climate may cause soil to blow away.

______ 6. Small animals and plants in the soil help to make better soil.

______ 7. Adding fertilizers can improve soil.

______ 8. Different plants may need different kinds of soil.

______ 9. Forest fires may cause soil erosion.

______10. It takes a very short time for soil to form.

______11. Soil erosion carried mud into rivers.

______12. Growing the same plants on a farm every year will (1) improve the soil; (2) injure the soil; (3) erode the soil.

______13. Sheet wash is caused by (1) plowing in dry weather; (2) gullies and rills; (3) heavy rains.

______14. Planting grass on a hillside (1) helps prevent erosion; (2) causes erosion; (3) causes gullies to form.

______15. Terracing a hillside (1) helps the soil keep more water; (2) lets more air into the soil; (3) improves the appearance of the hill.

Name______________________
Last First

______16. Contour plowing means (1) plowing up and down a hill; (2) plowing around the hill; (3) plowing in a zig-zag pattern.

______17. Soil erosion may result from (1) building too many houses in a city; (2) allowing too many animals to graze in the area; (3) allowing too many trees to grow in a forest.

______18. Soils may be protected from wind erosion by (1) putting sand in the soil; (2) building dams; (3) planting trees.

______19. Check dams are used to prevent further erosion in (1) dams; (2) gullies; (3)lakes.

______20. To prevent soil erosion after a forest fire (1) dams should be built; (2) the land should be cleaned off; (3) more trees should be planted.

Post test - GRASSLANDS

Name______________________________
Last First

True and False

______ 1. We should kill coyotes and wolves that destroy antelope.

______ 2. Soil erosion may be caused by overgrazing.

______ 3. Man uses many grasses for food.

______ 4. Soil with grass on it is able to hold more water.

______ 5. Rotating crops improves the soil.

______ 6. Deer could starve if they had only hay to eat.

______ 7. Some grazing animals eat mostly bushes and small trees.

______ 8. Grasses help prevent floods.

______ 9. Grasses should be plowed up to prevent prairie fires.

______10. Trees and bushes should be cut from pasturelands to allow more grass to grow.

______11. Birds in the grasslands build their nests in trees.

______12. Soil is built up by grasses.

Multiple Choice

______13. Strip cropping is used (1) to increase moisture in the soil; (2) to prevent prairie fires; (3) to enrich the soil; (4) to give the soil a rest.

______14. Lakes and reservoirs may fill up with silt (1) when forests grow on either side; (2) when grass is removed from surrounding country; (3) when dams are too large; (4) when hills are terraced.

______15. Before man began to use the grasslands there were (1) more floods; (2) more buffalo; (3) more gullies; (4) more dust storms.

______16. Predators that live in the grasslands are (1) buffalo; (2) mountain lions; (3) wolves; (4) antelope.

______17. When man plows up the grasslands (1) the soil improves; (2) the soil is exposed to wind erosion; (3) the soil holds more moisture; (4) more soil is formed.

______18. Many small animals that live in the grasslands escape their enemies by (1) climbing trees; (2) hiding behind rocks; (3) having sharp teeth; (4) burrowing in the ground.

______19. Forests would grow in the grassland if (1) there was less moisture; (2) there was more moisture; (3) the seeds of trees were planted there; (4) the soil was better.

______20. Large animals of the grasslands escape their predators by (1) running; (2) fighting; (3) climbing trees; (4) hiding.

Post test - FOREST

Name ______________________
Last First

True and False

______ 1. Forests cause the soil to dry out.

______ 2. Insects may damage a forest.

______ 3. Deer may damage forests if their population is not controlled.

______ 4. Forests can grow in any kind of soil if there is enough moisture.

______ 5. Some forests are raised as crops.

______ 6. Forest fires may cause floods.

______ 7. When trees are removed from a watershed dams and reservoirs fill with soil.

______ 8. If a forest is destroyed it can always be replaced by reforestation.

______ 9. Some hunting should be allowed in a forest.

______10. Forests help to maintain the water table.

______11. Cutting down a forest may cause floods.

______12. Trees help to prevent soil erosion.

______13. Recreation is an important use of forests.

Multiple Choice

(Choose the best answer.)

______14. Forests should be used (1) for recreational purposes; (2) to supply our lumber needs; (3) to provide range for livestock; (4) all of these.

______15. Overgrazing in forest areas will (1) cause forest fires; (2) cause erosion and floods; (3) help develop the soil; (4) prevent forest fires.

______16. To replace most forests that are destroyed will take (1) ten years; (2) twenty years; (3) fifty years; (4) more than fifty years.

______17. Some forests are used to manufacture (1)ink; (2) paper; (3) cloth; (4) cereal.

______18. Good forest management would (1) never allow any trees to be cut; (2) allow people to cut all the trees they needed; (3) provide for some cutting and some replanting; (4) plant larger forests.

______19. When a watershed is covered by forest the streams (1) are usually very clean; (2) are usually muddy; (3) carry a great deal of trash; (4) carry away soil.

______20. An animal that is harmful to a forest is the (1) bear; (2) beaver; (3) porcupine; (4) squirrel.

Post test - MINERALS AND OIL

Name ______________________

Last First

Underline some good solutions to the shortage of minerals

1. employ more miners
2. use low grade ores
3. dig deeper mines
4. increase market value
5. substitute synthetics
6. substitute alloys
7. reuse more minerals
8. discover new deposits

Underline consumers of minerals

9. industry
10. power production
11. communication
12. transportation
13. agriculture
14. manufacture of chemicals

True and False

______15. Oil can be used to produce power.

______16. We should reuse more minerals.

______17. Some countries have mineral shortages but the United States has a plentiful supply.

______18. Copper is an important metal in many industries.

______19. Power can be produced from uranium.

______20. Some minerals may be replaced by synthetics.

______21. Much of the oil we use now is recovered from oil shale.

______22. Oil can be reused.

______23. Alloys are combinations of metals.

______24. Water is heavier than oil.

Multiple Choice

______25. Lead (1) is used to construct rockets; (2) rusts easily; (3) has a harmful effect on people; (4) is a very light metal.

______26. A synthetic which has been successfully substituted for some minerals is (1) rubber; (2) limonite; (3) aluminum; (4) teflon.

Name ______________________

______27. There is still much oil that (1) we have not been able to find; (2) that we have not learned to extract economically; (3) we have not reused sufficiently; (4) we have not been able to purify.

______28. The most common metallic element found on the earth's surface is (1) aluminum; (2) sand; (3) iron; (4) copper.

______29. Iron is (1) slightly reusable; (2) reusable only when it is new; (3) highly reusable; (4) not reusable because it rusts.

______30. An ore is a substance containing (1) enough of a mineral to mine profitably; (2) a valuable metal; (3) iron; (4) a precious metal such as gold, silver, or nickel.

Post test - POLLUTION

Name ______________________________
Last First

_____ 1. City water systems remove all harmful chemicals from the water before it comes to our homes.

_____ 2. Companies which sell pesticides sometimes recommend that a larger amount than necessary be used.

_____ 3. The use of water in the United States each day is greater than the supply available.

_____ 4. Primary air pollutants are more harmful than secondary pollutants.

_____ 5. If the air is clear you can be sure there are no pollutants in it.

_____ 6. It is safe to empty radioactive wastes into streams because the water dilutes them to a harmless level.

_____ 7. Insecticides that will last for many years would be the best kind to use.

_____ 8. Twenty parts per million of sulfur dioxide in the air is harmful to humans.

_____ 9. The more insecticide a farmer uses the better he can expect his crops to be.

_____ 10. All pesticides become less poisonous after they have been in the soil for a time.

_____ 11. Aerobic bacteria live only where there is oxygen.

_____ 12. Coal burning industries cause most of the smog problem.

_____ 13. Aldrin and heptachlor are long-lasting insecticides.

_____ 14. Oxygen is a more powerful oxidizer than ozone.

_____ 15. Sewage treatment plants remove all organic material before returning water to a stream.

_____ 16. Many cities in the United States must use water that has come through another city's sewage system.

_____ 17. Viruses are killed in sewage effluent before the water is returned to a stream.

_____ 18. One person can do nothing to help solve our tremendous litter problem.

_____ 19. Litter can be an indirect cause of disease.

_____ 20. Many industries do nothing to purify their wastes before discharging them into streams.

______21. The Food and Drug Administration inspects most of the food we eat.

______22. People get residues of pesticides in the water they drink and in the food they eat.

______23. Most insecticides, pesticides and weed killers are harmless to humans.

______24. Automobiles may deposit poisons on food plants grown near the road.

Multiple Choice

______25. Aldrin and heptachlor are poisons that (1) evaporate quickly; (2) become harmless in the soil; (3) become more poisonous in the soil; (4) become less poisonous in a short time.

______26. Each year littering costs the taxpayers of the United States (1) $1,000,000; (2) $100,000; (3) $1,000,000,000; (4) $10,000.

______27. Fires starting in rubbish or litter destroy a home in the United States every (1) 12 days; (2) 12 weeks; (3) 12 hours; (4) 12 minutes.

______28. Pesticides washed into streams (1) are neutralized by water; (2) settle to the bottom; (3) may be concentrated by water plants and animals; (4) are diluted so they are harmless.

______29. Litter may be dangerous to us because (1) it is unfair for foresters to have to clean it up; (2) it costs us a great deal of money; (3) it provides breeding grounds for rats and insects; (4) it ruins the beauty of our land.

______30. A good insecticide should (1) last for only a short time; (2)kill all kinds of insects and spiders; (3) stay in the fields for many years; (4) be very poisonous.

______31. The pesticides that are used the most in the United States (1) become harmless after a short time; (2) disappear from the soil in a few months; (3) build up more and more poison in the soil each year; (4) evaporate into the atmosphere.

______32. Secondary pollutants in the air result from (1) primary pollutants combining; (2) temperature inversion occurring; (3) too many industries burning coal; (4) too many people burning trash.

______33. One of the most dangerous gases released into the air by automobiles is (1) ozone; (2) carbon dioxide; (3) sulfur; (4) carbon monoxide.

______34. Plants grown in soil that has insect poisons in it (1) are more nutritious; (2) take up some of the poisons; (3) do not take up any of the poisons; (4) have a bad taste.

Name ______________________
Last First

______35. The half-life of a radioactive element refers to (1) the length of time that half of the people exposed to the element would live; (2) the length of time it would take for half the weight of the element to go away; (3) the time it take for half of the radioactivity to disappear; (4) half the number of elements that become radioactive.

Post test - HUMAN RESOURCES

Name ______________________________
Last First

Check the statement in each group you believe to be most true.

1. A. Educated people are usually concerned with good government.
   B. Educated people are only interested in their own ambitions.
   C. Educated people do not have time to be concerned with government.

2. A. Highly educated people move often and far from their original location.
   B. High school dropouts move often and far from their original location.
   C. Highly educated people are more apt to settle in one locality and stay there.

3. A. The country needs more people who are willing to live on farms.
   B. There are more people living on farms now than are able to make a decent living.
   C. We have about the right amount of families living on farms.

4. A. People with high incomes usually move to the cities.
   B. Low income groups are increasing in the cities.
   C. Low income groups usually move away from the cities.

True and False

______ 5. When more money is invested in the Highway Patrol, accident costs are reduced.

______ 6. The West Coast is the region of most rapid population growth.

______ 7. The Negro population in the South is increasing.

______ 8. It is estimated that 20 percent of the population moves every year.

______ 9. The future expected output of the artistic, scientific, and judicial minds can be accurately estimated in terms of their economic value.

______ 10. Lack of education leads to poverty and unemployment.

______ 11. Education usually increases a person's economic value.

______ 12. Dropouts are concentrated in occupations having low incomes and high unemployment.

______ 13. High school dropouts can usually make just as much money as a high school graduate in their lifetime.

______ 14. There are approximately 12 million people living on farms in the U. S.

______ 15. Government money that is spent to educate people is a good investment.

______ 16. Public schools spend about 25 billion a year on education.

Multiple Choice

______17. The number of young people involved in police arrest is (1) less than 5 percent; (2) 10 percent; (3) 15 percent; (4) more than 20 percent.

______18. The people most likely to be unemployed are people with (1) a college education; (2) a high school education; (3) an elementary school education; (4) less than an elementary education.

______19. Crime increase is due to (1) more people committing crimes; (2) more crimes being committed by the same people; (3) more new crimes being committed; (4) more criminals.

______20. The person least likely to be arrested is (1) a person who has had a suspended sentence; (2) a person who is on parole; (3) a person who is on probation; (4) a person who has never been arrested.

______21. In a democracy an uneducated person (1) only harms himself; (2) is apt to be a liability to society; (3) is usually a good citizen; (4) is of as great a value as an educated person.

______22. People who are out of work are usually (1) too lazy to work; (2) not adequately educated; (3) too educated; (4) just no good.

______23. The value that should be considered in human resources is (1) a person's ability to earn money; (2) a person's spiritual value; (3) a person's contribution to society; (4) all of these.

______24. The leading cause of death in the United States is (1) tuberculosis; (2) influenza; (3) heart disease; (4) cancer.

______25. The population of the United States in 1968 will be closest to (1) 50 million; (2) 150 million; (3) 200 million; (4) 200 billion.

______26. The average life expectancy in 1965 was (1) 65 years, (2) 70 years; (3) 60 years; (4) 75 years.

______27. Education statistics indicate that in 1965 the number of people in the United States who were 18 or over and had less than an elementary education was close to (1) 2 million; (2) 20 million; (3) 5 million; (4) 50 million.

______28. The average age of the population is (1) getting younger; (2) getting older; (3) staying about the same.

______29. Today well-to-do people are moving (1) from small towns to cities; (2) from farms to cities; (3) from cities to suburbs; (4) from cities to the farm.

______30. The Job Corps is a government program that (1) trains unskilled and poorly educated people so they can find jobs; (2) find jobs for unemployed people; (3) supports people who have lost their jobs; (4) uses government money to make jobs.

Name ______________________
Last First

______31. According to the F.B.I. serious crime is (1) increasing at about the same rate as the population; (2) increasing much more rapidly than the population rate; (3) decreasing; (4) staying about the same.

______32. Money spent on education can be considered an investment if (1) people get jobs soon after being trained; (2) people stay on the same job and quit moving around; (3) it increases the long-term productivity of the person; (4) the government gets paid back within a few years.

______33. The most rapid population growth in the U. S. is taking place (1) on the West Coast; (2) on the Gulf Coast; (3) on the East Coast; (4) in Alaska.

Post Test -- ENVIRONMENTAL USAGE

Name ______________________________
Last First

Section I
True and False

______ 1. Some of the damage in the last Alaskan earthquake could have been avoided if houses had been built on more stable ground.

______ 2. Southern California has an adequate water supply from rivers in that part of the state.

______ 3. New York gets most of its water from the Delaware River system.

______ 4. Human societies must change the environment in order to survive.

______ 5. Earthquake-proof skyscrapers would be safe for people during an earthquake.

______ 6. Much good farmland has been covered with asphalt and pavement.

______ 7. It has been predicted that reclamation of farmland now covered by cities may eventually be necessary.

______ 8. Farmers near expanding urban areas are often forced to sell their lands because of high taxes.

______ 9. Urban areas have nearly always been carefully planned.

______10. Zoning laws could be used to protect farmers from unreasonable taxation.

______11. Anchor Dam in Wyoming is a good example of a successful, multiple-use dam.

______12. Building dams sometimes reduces the amount of water available from a river system.

______13. A real estate agent is the best person to ask about safe locations in an area subject to earthquakes.

______14. It is dangerous to build cities on fault lines.

______15. In construction and location of cities the natural features of the environment are always taken into consideration.

______16. Private gain is often in conflict with public interest.

______17. The way land and water should be used should always be decided by what the majority of the people want.

______18. Over half of the population of California has settled in an area where desert conditions prevail.

______19. The easiest areas available for urban expansion are often good farmland.

______20. America needs more and better highways for more efficient transportation.

Post Test - ENVIRONMENTAL USAGE

Name ______________________
Last First

Section II
Multiple choice

______ 1. More than half of the population of California lives in an area of (a) forest land, (b) desert conditions, (c) moderate climate, (d) heavy rainfall.

______ 2. Most cities in the United States are usually (a) zoned to protect farmlands, (b) carefully planned, (c) not planned at all, (d) careful to restrict building on dangerous sites.

______ 3. Southern California is an area that has (a) very little water available, (b) more water than it needs, (c) has just enough water to meet its needs without bringing water from other places, (d) developed the means to use sea water.

______ 4. Farmers living near large cities are apt to sell their land because (a) crops do not grow well near cities, (b) the land is worth so little, (c)smog increases the number of insects, (d) property taxes are too high.

______ 5. Anchor Dam in Wyoming does not hold water because (a) the water leaks out through the limestone bottom, (b) the rivers which flow into it have dried up, (c) the dam has cracks in it, (d) there has been very little rainfall since the dam was built.

______ 6. Farmland near urban areas could be protected by (a) passing zoning laws, (b) developing it for homesites, (c) having the Federal government use it for parks, (d) using it for shopping centers.

______ 7. The land most frequently chosen for urban expansion is (a) good farm land, (b) rocky, unproductive land, (c) hilly land, (d) forest land.

______ 8. The strata which causes Glen Canyon Dam in Grand Canyon to lose water is (a) limestone, (b) lava, (c) granite, (d) sandstone.

______ 9. A strata which may act as a slide plan when wet is (a) limestone, (b) gravel, (c) sand, (d) clay.

______10. If you plan to buy a house in an earthquake area, the best thing to do is to (a) ask the real estate agent about the danger, (b) hope the earthquake doesn't happen, (c) ask the neighbors about earthquakes, (d) ask a geologist about the stability of the land.

______11. An earthquake-proof skyscraper would be most dangerous during an earthquake (a) on the ground floor, (b) on the 5th floor, (c) on the 10th floor, (d) on the 15th floor.

______12. New York City gets most of its water supply from the headwaters of the (a) St. Lawrence River, (b) Hudson River, (c) Mississippi River, (d) Delaware River.

______13. The primary consumer of water of the Northeastern Seaboard is (a) industry, (b) laundries, (c) people watering lawns, (d) crop irrigation.

Name ______________________________
Last First

______14. The main water problem of the Northeastern states is (a) too much water, (b) not enough water, (c) salt water, (d) water pollution.

______15. One of the primary uses of land classified by the description "cultivatable with limitations, moderate slopes with only fair soil and drainage conditions" should be (a) urban, (b) grazing, (c) industrial, (d) recreation.

______16. One of the primary uses of land classified by the description "not cultivatable, steep slopes, thin soils, severe climate" should be (a) forestry, (b) croplands, (c) watershed, (d) grazing.

______17. The most immediate destructive force in national recreation areas is (a) the animals, (b) the recreationist, (c) earthquakes, (d) highways.

Section III
Completion

After each land description indicate the best primary land uses. (Use only the letters. Use as many letters as you think necessary for each answer.)

Land Uses

A. Cropland

B. Grazing

C. Watershed

D. Urban

E. Industrial

F. Forestry

G. Wildlife

H. Recreation

1. Cultivatable, gently rolling, wet to droughty soils, contour and strip farming, good soils

____

2. Cultivatable, flat, well drained, excellent soil

____

3. Not cultivatable, slight limitations from danger of erosion

____

4. Not cultivatable, moderate limitations from increased slope, fair soil and harsh climate

____

5. Cultivatable with limitations, moderate slopes with only fair soil and drainage conditions

____

TEACHER EVALUATION FORM

The following questions should be answered as accurately as possible, for the teacher's judgement and opinion is extremely important to the program for future planning.

Section I

Directions: Answer the following questions by checking the response column under the number corresponding to the meaning that best fits your opinion. (5: extremely helpful; 4: very helpful; 3: helpful; 2: somewhat helpful; 1: not helpful)

Questions	Responses				
	5	4	3	2	1
1. To what extent was the teacher's discussion helpful?					
2. To what extent was the teacher's reference of value?					
3. To what extent did the Unit development assist in presentation of the unit?					
4. To what extent did the Resource Unit assist in planning the teacher presentations?					
5. To what extent did the activities assist in presenting concepts to the students?					

ABSTRACT

This investigation developed and tested an experimental sequence of integrated conservation core units for teachers and students in grades 1 through 9 in five Wyoming school districts. The units developed were Grade 1 - Wildlife; Grade 2 - Water; Grade 3 - Soils; Grade 4 - Grassland; Grade 5 - Forests; Grade 6 - Minerals and Oil; Grade 7 - Pollution; Grade 8 - Human Resources; and Grade 9 - Environment Usage. General teacher's evaluations indicated the unit "Teacher's Guides" were very helpful, except for the Grade 6 unit which requires revision.

The ideal time for teaching each unit appeared to be 3 to 4 weeks. Analysis of variance evaluation of student pre-test and post-test responses indicated that the discovery and analysis approach suggested in each unit was successful. Consistently higher student performance recorded in all grades was registered in that school district having more teachers with conservation course and workshop training.